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AN AUSTRALIAN FLOCK

PITMAN'S COMMON COMMODITIES
AND INDUSTRIES

WOOL

FROM THE RAW MATERIAL
TO THE FINISHED PRODUCT

BY
J. A. HUNTER

FOURTH EDITION

LONDON
SIR ISAAC PITMAN & SONS, LTD.
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PREFACE TO FOURTH EDITION

THE opportunity has been taken to revise the statistical data, to remove passages which have been invalidated by the lapse of time, and to correct certain errors in statements of fact. A new chapter, "Fire Hazards of Woollen Mills and Woollen Warehouses," by Mr. Robert Taylor, Fellow of the Chartered Insurance Institute, has been added, in the form of an Appendix, and it is trusted that these changes are all of a nature to make the book more useful as a general introduction to its subjects.

PREFACE TO THIRD EDITION

To the addenda made for the purposes of the Second Edition have been added certain revisions and a new chapter relating to wool and woollen manufacture in time of war.

PREFACE TO FIRST EDITION

It is in broad terms true to say that cotton is the clothing of the East and wool the clothing of the West. Cotton forms the staple of attire in the hot and backward countries. Wool is the chief covering of dwellers in more temperate climes, and of those in general who have adopted Western standards of comfort. In a rather special sense wool is at once a measure and a signal of the advance of modern civilization.

The history of wool over a number of centuries is virtually the history of British commerce. From the earliest times wool or wool goods have formed a great part of England's foreign trade, and the utilization of wool for clothing goes back to the depths of antiquity.

In all ages, British wool and woollens have enjoyed a high reputation for excellence in the penetrable parts of the outer world. The manufacture is one in which our people have developed a marked special aptitude. and "English" or, it may be, "Scotch" or "Irish," remains the highest commendation the foreign tailor can bestow on the cloth he exhibits to his customer. The respect shown to those names is not diminishing, and although representatives of all nations come here to learn British methods, and although British machinery is used largely by them, the learners do not surpass the tutor.

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WOOL

CHAPTER I

WOOL AND SHEEP

THERE are in the world normally somewhat more than 500 million head of sheep, bearing more or less desirable classes of wool. The total is not one about which precise information is procurable. Censuses of live stock are of doubtful accuracy at best, and from some countries none is forthcoming.

The International Institute of Agriculture was able to account for 393½ million sheep in 1922 within an area which included about three-fourths of Europe and South America, one-fourth of Asia, four-fifths of Africa, and almost the whole of North America and Australasia. The extent of the flocks in the rest of the world, although conjectural and based upon statistics some years old, probably exceeds a further 100 millions.

As wool supplies are reckoned rather by bales of wool received at the recognized centres of distribution than by the head of sheep, the possible inaccuracies of the statement need not detain us. The sheep raising continents in the order of numerical importance are : Europe and the British Isles ; Australia with New Zealand ; South America, Asia, Africa, and North America.

The sheep of the world are found as far north as Iceland and as far south as the Magellan Strait, with the north and south temperate zones as their chief *habitat.* They extend into the semi-tropics, but only the higher altitudes in the tropical zone afford congenial

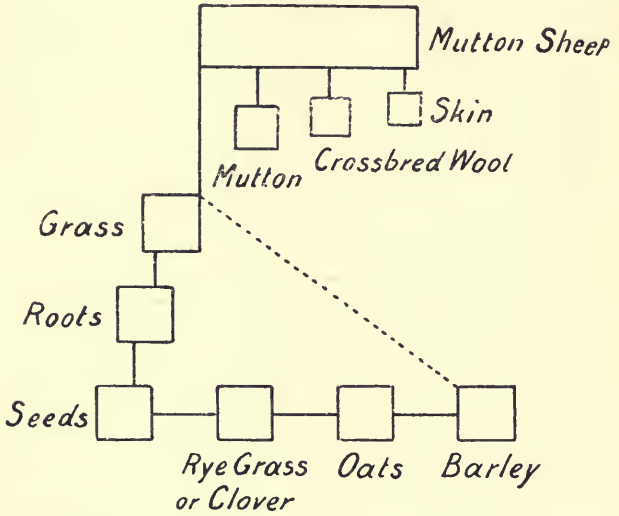
surroundings for producers either of good mutton or good wool. In numbers, and, to a smaller extent, in areas of distribution, there is a more or less continual change.

In Europe, which remains the chief sheep-raising (although not the chief wool-producing) continent, the number has dwindled in consequence of the pre-occupation with manufacturing industry and development of alternative methods of farming. In Australasia the otherwise continuous production of sheep is checked by such droughts as that which lasted eight years and ended in 1902. In Argentina the introduction of grain growing and the increased rental crush sheep southward into the colder country, Patagonia. In North America the closer settlement and the profit from grain restrict the development of sheep farming. South Africa has increased its wool production if not its number of sheep.

Naturally, in lands as far apart as these, the considerations which prompt agriculturists are various. The circumstances of farmers much nearer differ radically, but the sheep, despite differences of breed and country, is in one respect the same. It yields a double harvest, in mutton and in wool. The pastoralist in the grass lands of Australia, Argentina, South Africa, or any other country of uncertain rainfall, might, if he chose, pasture cattle on his run. They would be longer in coming to maturity, and hence in turning crops into cash. They would have a greater value per head, and expose him to more risk in case of deaths in the herd. They would require more water, and not be fat for market in dry seasons. A very substantial reason for placing sheep on a pasture fit for other animals is that it divides the farming risk.

The advantage is more complex, but no less clear,

in the case of the "mixed" farmer working both grass and arable land. To him also the sheep provides both wool and meat, but its services are farther-reaching. The sheep is a great clearer and improver of pastures, a provider of more and sweeter grass for other stock.



THE PRODUCE OF THE MUTTON SHEEP IN HUSBANDRY

Its manure is peculiarly rich, and indispensable in starting and maintaining the English rotation of crops. No terms of enthusiasm are unjustified in commending the part played by the sheep in transmuting grass into corn. A farmer with land which he wishes to make arable, ploughs it and sows a crop of roots. When the turnips ripen he folds his weaned lambs or hoggets on them. The hogs eat, return their droppings to earth, and tread in and distribute them automatically,

to the saving of labour. By the time the root crop is done, the hogs are ready for shearing and to return their first yield in the price of wool. They are fat and ready for the fat lamb market, where their carcasses fetch so much a pound. The turnip field is ripe next for a crop of seed grass which should sustain lambs, and their milking mothers, at the rate of five to eight to the acre from April to October. In the following year rye-grass is sown along with clover, and there is more rich grazing as well as a yield of hay. Oats follow and next barley, and the cycle begins again and continues endlessly without impoverishment of the soil. The animal which makes this farming magic possible is the sheep which in England gives not only wool and mutton but also corn.

Sheep-growers' costs have increased of late years in all parts of the world, and it is not easy to single out from mixed farming operations the costs and profits attributable definitely to sheep. A lamb and ewe of Hampshire Down breed used to cost, upon Professor Wrightson's calculation, some 30s. a year gross, and perhaps 26s. net when the value of the wool has been deducted. To pay for these and leave a profit there is the ewe's lamb, whose price is governed by the market. There is more than one lamb per ewe; out of 1,000 ewes of the breed in point, there should be reared and ready for market 1,100 lambs. Assuming a price for lambs that is neither the lowest nor the highest known, allowing for labour 1d. per head per week, and another 1d. for risks and expenses, Professor Wrightson's calculations show a profit of £2 per ewe, which in his case is the same as £2 per acre. The residuals in the land, the benefit to pasture currently and to succeeding crops are additional to the profit named.

The actual cost of wool production in sheep-farming

pure and simple is dependent upon many factors, including rent, the price paid for breeding stock, labour and carriage to market. The costs vary materially in different parts of the world, but it was calculated before the war that wool could be grown at an average cost of 6d. per lb. in the United States, 5d. in Australia, and 2d. to 2½d. in South America. Wool has been grown at an approximate cost of 9d. per lb. by representative Australian farmers in the season 1924–25. The margin between the absolute cost and the price realized in the market represents the inducement to farmers.

In Great Britain, sheep are kept partly because nothing pays better, partly because to make a change from the system of which the sheep is the keystone must involve a ruinous capital loss to farmers. If they wished, they could not without wasting the fruit of years, copy Denmark, and put farming upon a basis of which the cow should be the foundation. Flocks may, and will, fluctuate in number in countries where mixed farming is pursued, but there is no serious likelihood of the extinction of the sheep in them. Where the unthrifty one-crop system of agriculture is practised, sheep dwindle and are relegated to the bare grounds, the badly-watered lands, the ranges far away from the railway. In Ontario they are bought in small numbers as a "flying flock," and penned on a pasture to eat away the tough grass and weeds distasteful to cattle, and are then sold again. In the Eastern States of America sheep are little kept, apparently because of the high price brought by grain and the nuisance of sheep-feeding during winter.

Sheep farming in the neighbourhood of towns and villages suffer discouragement from dogs, and in industrial districts somewhat from smoke, but, given freedom from great climatic extremes, with grass, water, and

dry ground, one breed or another of sheep will thrive there with ordinary attention. Great Britain provides instances of the extraordinary adaptability of sheep. The Scotch black-faced mountain sheep, valued for their sweet mutton rather than for their coarse carpet-making wool, are found alive but emaciated after a burial of weeks in a snowdrift. When the shepherd is at length able to dig them out he finds that they have subsisted upon their own breast-wool and such portions of heather and heather-root as could be reached without moving more than their heads.

Differences of size, appearance, hardiness and suitability to local conditions appear between every two breeds of sheep, and these are accompanied by marked differences in the quantity and character of the wool borne. In the United Kingdom we have highland and lowland sheep; short woolled animals of which Down sheep are the generic type, and long-woolled ones like the Leicester and Lincoln. The wools range in length from three to four inches, when they are suitable chiefly for flannel and hosiery, up to fifteen inches long, when their suitability is determined by their characteristics of coarseness and lustre. The coarsest wools are at least seventy times thicker in diameter than the finest, and in curliness, softness, and colour, there are most conspicuous differences. The variations are vital in determining the manufacturing uses, and in England, where sheep are kept for mutton more than wool, are of greater concern to the manufacturer than the farmer.

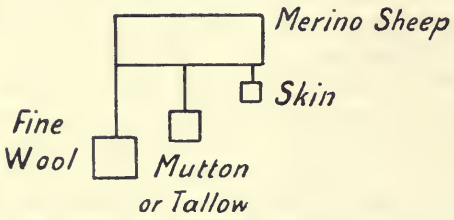
The breeding of pure types of the best English sheep is carried on as well for home as export purposes. Lincolns, Leicesters, Southdowns, Romneys, Wensleydales, Shropshires, Dorsets, Oxfords, and Cheviots, out from England, mingle their blood with merino

and local sheep in nearly all countries. Each breed has its own votaries who are grouped into associations, each with its own flock-book and rules for the registration of stock and tabulation of prices and exports.

The pure breeds are the fixed types; the ones which have the power of transmitting their characteristics to their progeny indefinitely. The majority of British sheep are not pure but crossed or half-bred to suit the local conditions of farming. A farmer will use, for example, Leicester sires and Cheviot ewes for the general purposes of his business and this intermarriage of long-woolled and shorter-woolled breeds produces wool of an intermediate type. The system is followed sometimes to the disadvantage of the resultant wool. Farmers, for instance, in seeking to produce a larger carcass or one of earlier maturity, employ rams of dark-faced breeds. The grey, black or brown hairs appear only on the face of the male parent but the inheritance comes out often in the fleece of the offspring, where it is detrimental to the commercial value of the farmer's clip.

The merino sheep, the bearer of the very finest wool, ranging in fineness up to $\frac{1}{3500}$ths of an inch, and woolled so closely that there are from 40,000 to 48,000 fibres per square inch of skin, is of the type that is not grown directly for the sake of its mutton, although the flesh of some flocks is good. The carcass is small, the lamb comes to maturity relatively late, and the fat is strong in flavour, but the merino has many virtues. It is an industrious feeder and requires little water, and, unlike the English sheep, can be housed in sheds in winter without contracting serious ailments. The merino is not farmed in England, but directly and indirectly it provides the bulk of the commercial supply of the world's desirable wool.

The merino was confined originally to Spain and its wool made the reputation of Spanish cloth in past centuries. George III obtained a few animals by gift and imported them to England where they had a very qualified success. The Royal flock was being broken up in 1804 when Captain John Macarthur bought and took to New South Wales eight of these sheep, thus laying the foundation of the Australasian wool industry. The experiment met with immediate success. The yield of wool from the existing sheep in Australia was



THE PRODUCE OF THE MERINO SHEEP

raised from 3½ lb. to 5 lb., and has been increased progressively since by the introduction of new strains of merino blood and the careful adaptation of breeds to their surroundings.

Wool is valuable in proportion to its fineness, and Australian merino wool may be graded into three distinct types: Fine, coming from the temperate and better-watered regions near the coast; Medium from pastures of more uncertain rainfall; and Strong from the scorched and dusty plains upon which the feed is precarious. The animals bearing these wools exhibit a corresponding difference in size and build, the strong-woolled weighing nearly twice as much as the fine-woolled. In length of staple the Australian merino wools range from 2½ in. to 6 in., and they vary as

A PRIZE SOUTHDOWN RAM

greatly in diameter and in waviness. Wool fibres show undulations or crimps along their length, and the finer the wool the more of these waves there are to the inch. In a fine merino fibre, straight from the fleece, about twenty-four crimps to the inch is usual, and in a strong merino about sixteen. New South Wales and Queensland provide merino of all three types. The " Port Philip " wools, which are valued especially for their colour and brightness, are grown in Victoria. Western Australia produces merino of the strong type, stained reddish by the soil.

New Zealand merino approximates to Victorian wool in its silkiness. Cape merino, largely grown upon the descendants of Australian stock, is spoken of as " papery," short, fine and dry, lacking the bulkiness and springiness of Australian wool, but by virtue of its character it serves special uses in cloth manufacture. South American merino from Uruguay and Argentina is short and distinct from either the Australasian or the South African types, and has found its chief appreciation upon the Continent mainly for conversion into soft dress goods.

The merino is to the sheep what the Arab thoroughbred is to horses and the Americans speak of it as the blood animal and its wool as blood wool. A century and a half ago Spanish merinos were introduced into Saxony, and in the early part of the last century Saxony merino was the finest wool on the market and was imported in some quantity to Great Britain. The name of the wool was applied to the cloths made from it, and in Scotland and some English woollen districts merino is still known as Saxony although the wool is not of that origin. The first merino wool from Australia, being shipped from the convict settlement, Botany Bay, got the name of Botany which has clung to it

SHEEP OFF THE SHEARS, NEW ZEALAND

and is the name commonly used for merino in the Bradford market.

Names are employed somewhat loosely in the wool market, and in one sense all sheep of crossed breeds are entitled to be called crossbred. But the crossbreds of the Colonies and South America are sheep crossed with the merino blood, and when crossbred wool is mentioned imported crossbred is to be understood. By breeding from a British ram and a merino ewe an animal of larger frame with a heavier fleece and with coarser wool is produced. The crossbred animal furnishes the frozen mutton of commerce, and since the great development of refrigeration on shipboard and cold storage ashore, dating from the early 'eighties, its culture has enormously increased. The crossed breeds require more water than the pure merinos, and economy requires that they should not be grown too far away from the refrigerating works. Four-fifths of the New Zealand flocks are crossbred, as are nearly all the sheep of Argentina, and their wool reflects the character of their parentage. Leicesters, Lincolns, Shropshires, Romney Marsh and Roscommon sheep, Southdown, Hampshire Downs and Oxford Downs are the English breeds most used, and their offspring supply the main part of the medium wools used in England.

Crossbred wools are less fine than pure merino, but they are anything but homogeneous. Crossbred is crossbred whether it comes from the mating of a long strong, lustrous woolled animal like the Lincoln, or a short woolled Down sire with a merino ewe. It is crossbred also whether the cross is a first-cross producing a lamb of exactly half-breed or whether it is a later descendant. Half-bred ewes are coupled with merino rams to breed animals that are three-quarters merino. An animal seven-eighths merino is born

when the third generation of mixed blood is again fertilized by the merino strain. In consequence there are crossbreds that are almost English in type and others so near to merino that they receive the name of "comeback," signifying that after several generations the wool has reverted almost to the original merino type. Three distinct types of crossbred are recognizable as fine, medium and strong, each available for purposes for which the others are not suitable.

The separate kinds of wool are useful each for its own class of goods, and the distinction between merino and crossbred, to which last may be added homegrown wool, runs through the industry. The worsted industry is divided substantially into these two branches, and in a less degree the same is true of woollens. The fine and the coarse wools require different, or differently adjusted, machinery, and that which is suitable for the one is less suitable for the other. To some extent the two sorts are competitive, for fashion swings from one to the other, assisted at turns by abnormal disparities of price. There is a normal distance between the prices of the two which is liable to be exceeded —thus the shift of fashion from soft goods to harder ones tends to bring back the equipoise.

In thinking of wool the tendency is to think only of that which is shorn from the live sheep, ignoring the large quantities of "skin" wool removed from the pelts of slaughtered sheep. Prejudice against wool from the dead sheep has not disappeared from manufacturing circles, although it has been lessened by experience gained in working the large quantities of skin wool that have been brought into commerce by the development of the mutton trade. Skin wools are mixed often with fleece wools in blends both for worsted and woollen, and when so used their reputed harshness

and inelasticity are minimized. The so-called " slipes " are wools removed from the skin after steeping in lime-water until the fibre is loosened at the roots. Objection is taken to the presence of lime upon the wool and other means of removal are practised. At Mazamet (France), the chief European centre for skin wool, sheep-skins from South America and Australia are treated by a simple putrefaction process, being hung in moist air until the progress of fermentation allows the wool easily to be pulled away. Chemical agency is sometimes employed and the skin is painted with sodium sulphide in solution, when the loosened wool can be plucked from the skin.

Accurate account is kept of the receipt and shipment of wool at the ports of the chief exporting countries. The totals are cabled without delay to the centres of industrial consumption. They form a check upon the estimates of supply and demand and are of importance in guiding commercial opinion. The most influential are the reports received from Australia and Argentina.

In early August a statement becomes available to show the estimated production in Australia and New Zealand during the twelve months ending 30th June, together with a summary statement of the sales by quantity and value. In October details are received of the exports of wool from the River Plate in the wool year ending 30th Sept. Much less precise information is obtainable about wool grown within the manufacturing countries and moved to the centres of industry in small and casual lots. From the minor source of supply information is received more dilatory, and the news from the main source is in any case of more commercial influence. The value of wool is most affected by the quantities arriving at the principal markets and the considerable aggregate quantity consumed at or near the points of

production is of less account in determining the course of prices.

Estimates of the total volume of the world's supply necessarily include more or less dependable computations of quantities of local wool such as do not enter into the larger markets. It is computed by the U.S. Department of Commerce that the world total reached in 1925 some 2,892,400,000 lb., compared with 3,231,500,000 lb. in 1913. The particulars may be summarized—

Australasia—	1913	1925
Australia	705,146,000	735,000,000
New Zealand	198,474,000	170,000,000
	903,620,000	905,000,000
Europe	570,347,000	535,369,000
South America	578,026,000	446,283,000
North America	332,330,000	319,834,000
Africa	219,694,000	246,600,000
	2,604,007,000	2,453,086,000
Rest	627,470,000	439,330
	3,231,477,000	2,892,416,000

The British Empire furnishes, upon this estimate, three-sevenths of the wool supply of the world. The quota is more important qualitatively than quantitatively because the material is in general the more highly prized and fit for making the most valuable goods.

The sheep is the great provider, but in addition to wool from the sheep is wool, or wool-hair, from the goat. Mohair, the produce of the angora goat, is commercially the most valuable and important material, and it is finer than the hair of common goats just as the hair of angora cats and rabbits is finer than that of the common species. The hair is white or of a yellow cast, growing in long glossy ringlets upon the animal's back, and the most highly prized variety is that grown in Turkey, from whence the export of live mohair goats

has long been forbidden. Angoras have, however, been taken to other parts of the world, and about three times as many angoras are maintained in South Africa as in Asia Minor. The produce is known respectively as Turkey and Cape hair, and the highest price is obtained for the first shearings known as Cape kids. The angora has been introduced in North America and is run on large tracts of land in New Mexico, Arizona, Texas, California and Oregon.

The alpaca, with which mohair is popularly confused is the hair of the South American llama, *Auchenia paco*, which ranges the Andes. Whereas mohair is white, alpaca is of mixed brown, grey and black colour with a very small proportion of white. Alpaca is unsuitable for dyeing to any other colour than black, and in order to dye it to a full black shade a proportion of white hair is wanted with the coloured. Thus the white hair is considerably the most valuable of any. Arequipa alpaca commands the best price, and next Tacna, Callao, Chala and Huarizo ; names derived from the sources of origin.

Vicuna, the produce of the goat of the same name, is a rare material forthcoming in very small quantities from Peru and commanding four or five times the price of the best alpaca. Vicuna may be compared with the hair of the Kashmir goat, of which the finer sorts are used to make shawls which sell at extremely high prices. Commoner forms of cashmere shipped from North China provide a soft material for high-class knitted underwear. Except in colour a similitude can be traced between the ordinary cashmere of commerce and camel hair. The camels which provide material utilizable as wool are those of the northern latitudes, principally of the great Asiatic desert, and their hair is forwarded to market from the edges of that desert in

Russia and China. Camel hair is fawn while the predominant colour in cashmere is blue-grey. Both materials include a coarser beard or upper-hair with a downier undergrowth, and when separated in the process of manufacture these sorts serve separate purposes, the one giving soft underclothing and the other going to make carpets, driving belts and filter cloths.

The commoner goat furnishes coarse hair that is often used in substitution for curled horsehair in stuffings, and is rarely spun into yarn. The goats of finer breed yield hair that is practically a wool, and on the other hand are sheep producing wool so coarse as to be almost hair. Manufacturing uses are found for these coarsest wools, and even for human hair imported in queues from China. Canvas of great resiliency is made from mixtures of the coarsest wools and human hair and employed by tailors as an interlining in making coats as a substitute for the stiffer fabrics made from horsehair. Tail hairs from the horse are handwoven across a cotton or a worsted warp to make the tailor's crinoline cloth, each hair being individually inserted by the weaver. The horsehair used for seatings, and for stiffenings, is at one extreme and an ultra-fine hair combed from captive Angora rabbits is another. Neither is strictly wool, but this long, fine rabbit fur has the interest of a curiosity. It is produced and used in France by manufacturers of light, warm and costly wraps.

CHAPTER II

THE WOOL INDUSTRIES

" A FAIR business is passing in 60's, little is doing in qualities between 50's and 56's, and Topmakers report that their whole production of 40's to 46's is sold."—*Extract from a Bradford market report.*

Numbers like those in the quoted passage appear and reappear whenever wool is mentioned, and in this instance denote the quality of tops (i.e. long wool scoured of grease and combed free of its shortest fibres). The numbers shield the identity of the more familiar names, merino and crossbred. Sixties are the typical merino; forties are coarse crossbreds, forty-sixes are the medium, and fifties and fifty-sixes are the fine crossbreds approaching to merino in quality. These numbers are based on yards per pound, and in the beginning—if not at the present—to describe wool as sixties implied that one pound of the combed top would, when spun into worsted, give a uniform yarn of such fineness that sixty hanks, each of 560 yards, would go to the pound.

These numbers are the property of the worsted trade, which is that section of the manufacturing industry that is concerned with the longer wools. The shorter fleece wools, the shorter fibres of long-woolled fleeces, and the wool removed by the wool-comb are the raw material of the " clothing " or carded woollen trade. The distinction between short and long, like the distinction between merino and crossbred, marks another major division, and a more abiding one, running throughout the industry. The wool comb, a machine devised to select the longer fibres and to draw them

parallel, has been so modified as to accept material shorter than did the combs of a few years ago, but there is a minimum limit to the length it can take. The carding industry is equipped with machines designed to intermix the longer and the shorter fibres, and to cause the former to carry the latter.

The distinction between worsted and woollen is a broad one following the indicated lines. Worsted and woollen often meet in the same fabric, the former serving as warp and the latter as weft. They pay each other the compliment of conscious imitation, combed wools being sometimes spun on machines to make them as much like woollen as possible, while woollen cloths are in some circumstances finished to resemble as nearly as may be, carded woollen goods. Despite their occasional correspondences, worsted and woollen remain distinct, using different material, different machinery and processes, and producing different classes of goods. The woollen industry is the consumer of the by-products of the worsted manufacture and the utilizer of the great reserve store of woollen material which exists in the form of rags. The one employing the long and the other the short wools, the two complete the economy of the industrial scheme.

Worsted employs the more persons, but the woollen manufacture is carried on in a larger number of premises. In England the worsted industry tends to a strict subdivision of function. The comber combs, the spinner spins, and the manufacturer weaves, quite commonly without carrying on any other considerable function. The woollen mills are more self-sufficing, the manufacturer is carder and spinner as well, and often dyer and cloth-finisher too. The worsted industry has had a large foreign business in tops and yarn, which are not

converted in this country into any kind of cloth. The woollen mills export but little in a half-finished state.

Taking the industries as a whole it is estimated that in 1907 there were produced in the United Kingdom 243,500,000 lb. of combed worsted tops with 260,000,000 lb. of woollen and worsted yarn, and that there were woven 397,234,000 yards of woollen and worsted cloth irrespective of carpets, blankets, flannels, and some minor articles. The yardage includes goods woven on cotton warps or otherwise mixed but known ordinarily as woollens, worsteds or stuffs, and it neglects the considerable quantity manufactured into fabrics or garments not by weaving but by knitting. The particulars are the latest available pending the publication of the details of the succeeding census of production (1926).

Breeds of sheep and types of wool vary by districts, and are classified according to their locality, and the same is the case with mills and with their products. The cloths of one district are so nearly alike as to be clearly distinguishable from those of another, be it a very few miles away. The typical Bradford worsted coating may, with a moderate degree of expertitude, be recognized as different from the typical Huddersfield article. Batley woollens proclaim their difference from Morley and Guiseley or Colne Valley woollens at a glance. English worsted differs from Scotch worsted in appearance, and Yorkshire tweeds from Scotch and Irish ones in touch. Particular branches of industry tend to grow and develop in the same place, and generally in the same manner as that in which the branch was first introduced. The industry may be bodily transferred, as the worsted stuff trade was from Norfolk to Bradford in Yorkshire, under stress of changes brought about by the introduction of steam and machinery. The face of the industry may be transformed as in

Gloucestershire, the ancestral home of the manufacture of broadcloth. All industry is in a condition of flux and change, but the lineage of standard manufactures can still be traced through generations to particular district origins, and as the changes affect the surviving trades in a given district much in the same way, the family resemblances are retained and perpetuated. The effect of a century of steam and machinery has been to concentrate the British wool manufacture principally in England. Of the seventy and odd millions worth produced in 1907 over £63,500,000 are credited officially to England and Wales. Six millions worth, or less than one-tenth of the value, was produced by the mills of Scotland, and £607,000 by Irish mills. The manufacture has been concentrated chiefly in one part of England—Yorkshire, to wit, and further in one part of the West Riding of that county. Yorkshire claims roughly two-thirds of the mills, substantially all the rag-grinding machines, 90 per cent of the wool combs, two-thirds of the spindles, four-fifths of the looms, and two-thirds of the workpeople. These are contained chiefly in a quadrilateral of which Haworth, Otley, Wakefield, and Holmfirth form the corners, and of which Bradford is the approximate centre. In Yorkshire the lowest and the highest meet. Some of the most expensive worsted and the least expensive woollens, the finest dress goods and the coarsest stuffs, the most genuine of articles and the least blushing imitations, are produced at points almost within eyeshot of each other.

Outside Yorkshire, the tweed trade of the South of Scotland composes the largest group of mills. The mills number 53, have an output estimated at £3,000,000 in value, and engage some 12,500 persons. These are carded woollen mills, making the all-wool tweeds of

which the whole world knows, and doing some worsted weaving. Worsteds were taken up in the dark days of the Scottish industry, and treated with the freedom and daring in design that has made tweed from the same source famous. Shirtings and dress goods are woven near Glasgow, and isolated tweed mills exist in the Highlands. A thriving hosiery trade is done around Hawick, and Greenock has a flourishing worsted spinning and knitting mill. Ayrshire makes blankets, and Alloa knitting yarns are of the highest reputation, but the Border tweed trade comes first in the Scottish industry.

The handloom for weaving cloth is less severely handicapped in competition with power-driven machinery than the spinning wheel formerly used to convert wool into yarn. The handloom weavers of the Western Highlands, as in Ireland and elsewhere, depend more exclusively upon the factories for yarn. The total product of the handlooms is insignificant in amount and less distinguishable than formerly from mill-made cloths. Goods genuinely hand-spun, hand-woven, and hand-finished command a sentimental preference. The idea that home-made goods demand more or higher skill and pains than the power-woven ones is entertained most readily by those who know least of the labours of the mill and of the wealth of ability that is lavished on the manufacture of cloth.

In the West of England manufacture and agriculture are carried on side by side and Stroud is the chief industrial centre. Important mills are found at Frome, Trowbridge and Wellington, and as far south as Buckfastleigh in Devonshire. The district extends to Chipping Norton and Witney, Oxfordshire, and despite the many changes occurring in its long history the West of England produces probably more cloth than

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WOOL AT THE MILL

ever, and its high name for good quality has never been sacrificed. The fine-faced plain broadcloth of our grandfathers has been replaced by worsted in Sunday suits, but there is a continuous demand for doeskins, beavers and meltons for overcoats and livery, and the district produces the best of these and the finest billiard cloths in the world. The production has been diversified, and it includes riding tweeds, cricket flannels, fancy tweeds and fancy worsted and woollens, serges and knitted puttees.

The Irish mills are woollen ones of growing reputation for fancy tweeds made from Irish and English Down wools, and for the national frieze, situated principally in Cork, Dublin, Athlone and Galway. A hand-weaving business of importance exists in Donegal Wales continues in a relatively small way to make flannels and to deserve a good name for them. Rochdale is the chief base of the flannel trade, and Bury in Lancashire has a manufacture of blankets. Lancashire has, in the Rossendale Valley, a substantial monopoly of the manufacture of woollen felt. In Leicester worsted is spun for hosiery, and worsted has long been spun in Darlington. In Westmorland there is a limited production of saddler's woollen cloths. Cumberland produces tweeds, for caps and other purposes, at Carlisle, and scattered about the counties are detached industries of smaller account. These isolated centres do but emphasize the great accretion in and about the West Riding.

To answer why the West Riding has become the home centre of the trades would involve too large a draught of history and geography. Observe simply that worsted yarn was spun there before Bradford—on the breaking up of the East India Company's monopoly—succeeded in attracting to itself the weaving trade. Observe that the West Riding is near both coasts, has cheap fuel and

large water supplies, and is where the iron and mechanical trades have developed also. Like other textile trades, the woollen and worsted ones provide abundant employment at tasks suited to women and children, and in the North of England there are many other industries to find husbands and fathers work. There were physical advantages, and there was a nucleus of workpeople with an understanding of the nature of wool and of the manual method of converting wool into yarn, and yarn into cloth. The combination has proved irresistible within its own scope, alike against other districts in this country and against the manufacturing genius of other countries. Nowhere are cheap tweeds made better at an equal price, and nowhere has the combing and spinning of strong and crossbred wools so prospered. The West Riding woollen and worsted industries are national specialities as well as local ones.

The machines used in making British yarns and cloths are themselves British with only unimportant exceptions, and are made in the districts in which they are most in use. American ingenuity has appreciably improved on the older method of winding yarn, and an Englishman in American exile created the automatic loom which is tardily coming into the service of the worsted business. The Continent has furnished new ideas for the construction of machines for dyeing and finishing, but in general the machinery is English in conception, design, and build. The proximity of manufacturer and machinist is inestimably beneficial to both sides. The more he knows of industrial requirements the better the engineer can meet them. The manufacturer derives his benefit in prompt repairs and supply of spare parts, and in obtaining machinery at first hand and first cost, with none of the packing charges, railway carriage, ocean freight and duty which

swell the cost of the same machines to many competitors abroad. Textile machine making has been organized on a basis of cheap production and comparatively small profits, and from the consequent low prices the home manufacturer benefits more than anybody.

The machinists who equip the home mills equip also foreign ones. Bradford combs and Keighley spindles; Huddersfield cards and mules; Bradford, Keighley, and Huddersfield looms, work in all parts of the world, and in the home market makers of these prime machines have hardly one foreign competitor in sight. The export of machinery has been at various times spoken of as prejudicial to British manufacturing interests, but in affording employment for large numbers of men the export has the accompanying effect of liberating numbers of women for textile employment. Then, where British machinery is used abroad there is a demand for English managers and overlookers at good salaries, for English accessories to accompany the machines and, frequently, for English materials to be worked upon them.

With the advantages at his disposal the British manufacturer has made himself easily the master in the production of the forms of goods to which he has addressed himself. For one reason or another business of certain sorts has been left alone. Only to a restricted extent have parties to the British worsted trade taken up the types of machinery used on the Continent for combing the shorter merino wools and spinning them into soft, full-handling yarns for making soft, plain dress goods and for the knitting trade. The combs and mule spindles required have in general a lower output than those in common use in this country, and in an ordinary way cannot be called more profitable to operate. The type of machine in use plays its part in determining the raw material to be chosen, and hence

British and Continental worsted firms have used somewhat different materials and have produced distinct and separate classes of goods.

Woollen manufacturers in England have, with marked unanimity, left to the Continental competitor the business in woollen yarn spun to more than a certain pitch of fineness. Both woollen and worsted manufacturers have preferred a large output to a small one, and have not of their own choice engaged in the weaving of goods having a great many threads to the inch. The reluctance has not arisen from inability but from conviction that their choice was the better one from the commercial standpoint. The reluctance has been increased by the knowledge that those undertaking these classes of business upon the Continent paid a lower scale of wages than their own and had therein an advantage in the manufacture of articles in which the labour expense is relatively high.

Were British manufacturers to attempt precisely the same class of trade as that done by their Continental competitors they must needs change their materials, machines, methods and objects—not inevitably for the better. They have had the mortification of seeing their patterns imitated by foreign competitors using lower grade materials. From time to time fashion has favoured the less solid articles manufactured abroad at the expense of the intrinsically superior articles made in this country. These temporary conditions are wont, however, to rectify themselves.

CHAPTER III

WOOL AND ITS MARKETING

When wool is clipped from the sheep at shearing time, the individual fleeces, rolled together and tied—in a proper order of things—with a loose twist made from their own fibre, are flung into a heap. The wool is packed by trampling into canvas bales and sent to auction sales or left in the heap to await the arrival of buyers. The statement outlines the practice in England, but in Australia and New Zealand, where shearing and packing are done on a grander scale, more elaborate preparations are made for market. The Australian sheep is "dagged" two or three months before it is shorn, to save the blunting of shears at clipping time, and to spare the animal the necessity of carrying about pounds of matter interfering with the further growth of the fleece. In shearing, the belly-wool, which, by comparison, is short and tender, is severed first, the locks from the legs and elsewhere follow, and the rest comes off as one continuous fleece. The locks, pieces, and belly-wool are packed separately from each other, and the main body of the wool classed as "firsts" or "seconds," "clothing" or "combing," is packed separately and marked with the station brand and the wording denominating its quality. Largely because the wools are graded so carefully and honestly Australasian wool commands so ready a confidence and so good a price. The buyer has little fear of finding dirt and inferior wool in the heart of the bale, or secreted in the middle of the rolled fleece. Separated, each quality fetches its best price;

miscellaneously mixed, so that nobody knows how much that is not wanted must be taken with that which is desired, wool does not realize its utmost value.

English wool is not classed regularly by the grower, although by all good farmers the fleece is "skirted" and the damaged portions are removed. The inclusion of inferior portions deceitfully is a kind of fraud probably less prevalent now than ever, but still not unknown. This, which is called "false winding," is a matter on which our forefathers were severe. A statute of Henry VIII declared that: "No person shall wind or cause to be wound in any fleece any wool not sufficiently rivered or washed, nor wind nor cause to be wound with any fleece clay, lead, stones, sand, tails, deceitful locks, cots, lamb's wool nor any other deceitful thing whereby the fleece may become weighty to the direct loss of the buyer." The "rivering," or washing of sheep, shortly before clipping time remains one of the distinctive sights of the English pastoral district. The sheepwasher, up to his middle in midstream, or standing outside the tank that also serves for disinfectant "dipping," seizes the swimming animal and souses it below the surface, rubbing vigorously with one hand to liberate the loose dirt in the fleece. A week or so later, and preferably before the yolk has had opportunity to rise again in the fleece, the shearing follows.

Clean, well-tended, and honestly packed though it be, the British farmers' wool is not necessarily in a condition to be bought advantageously by the consumer. Usually, the produce passes to a dealer's or stapler's hands to be further prepared by the removal of inferior portions or the putting together of similar fleeces or parts of fleeces. The wool is separated into "hog" and "wether" accordingly as it is the first-shorn or the product of a second shearing; or the fleece is broken

up into " matching," that the consumer may have only the single quality he requires. There are differences in length and fineness in wool from the same sheep. The finest occurs on the shoulders, and the wool is progressively coarser the nearer it grows to the breech. The difference is immaterial for some purposes, and matters little to the woollen trade, but in some other cases the penalty of mixing the sorts is found in unequal yarn and faulty cloth.

It is after a number of handlings that the material is committed to the woolwashing machine. The machine is a succession of troughs, containing soap, alkali, and warm water, through which the wool is propelled gently and gradually on the teeth of swinging rakes. The washing is followed by drying, done usually by a hot air-blast, the wool meanwhile travelling forward and being turned to ensure equal drying throughout. The effect of the treatment is to clean the wool and make it appreciably lighter in weight.

The loss of weight consequent on the abstraction of grease and dirt is variable. One hundred pounds of home grown Lincoln wool comes out weighing from 85 to 75 lb., while the same gross weight of merino may yield as much as 50 or as little as 25 lb. The figures throw a light on the difficulty of the woolbuyer's task. He has to judge the quality of the wool he sees and determine its general fitness for his work, which possibly presents no extreme difficulty. To estimate within 1 or 2 per cent what the net yield will be from a mass of wool, grease, seed, and sand, the unwashed produce of some hot, dry country, is a naturally different task. The buyer receives no encouragement to err by an average of more than 1 per cent, and there are in the trade a few hundred woolbuyers, from England, Germany, France, and America principally, who can

be trusted to buy wool upon the average within this narrow limit. They troop to Australia once a year to attend the round of auctions, and others assemble every two months or so in the London Wool Auction Room in Coleman Street. Their mornings are spent in the dock warehouses sampling the bales that have been sent there by the grower or the financial company that has advanced funds on the security of the wool. Their evenings are occupied in the sale room, where wool is knocked down to the first giver of the highest bid by the presiding selling broker.

The greater part of the Australasian clip is sold by auction in the coast towns of Australia and New Zealand to buyers out from England, the Continent, the United States, and Japan. The clip was at one time sold almost entirely through London, and the respective claims of the rival markets are a constant theme of discussion. Whether in London or Australia, the lot is knocked down to the bidder of the highest price, whose bid is determined by the conditions prevailing in the market at the time. Those who sell in Australia sell soon, and those who consign to London sell later, and it is sometimes advantageous to sell, and at others to wait. Buyers certainly do not cross the world to pay more money than they need, and sellers do not give their selling-orders at home if they expect to realize better abroad. In some states of competition a larger selection of particular classes of wool is available in the Australian market, but this depends upon the policy of sellers for the time being. The London auctions clear about 750,000 bales a year, and the Colonial ones dispose of amounts ranging up to 2,000,000, and in favourable conditions some reselling of wool bought in Australasia occurs in London.

As well as colonial wool, quantities of foreign wool

are sent to London and Liverpool, the supplies from the River Plate being the most important. Spanish, Portuguese, Icelandic, Moroccan, Persian and Peruvian wools of a generally coarse nature and classed as "low" or miscellaneous are among the number. The East Indian wools rank with these and their market names are redolent of their origins — Vicanere, Joria, Candahar, Pac Pathan are some of them. These coarse wools find their chief employment in making carpets, cheap blankets, and rugs.

London remains the chief primary European market for Colonial wool, and Dunkirk and Hamburg have replaced Antwerp, as the chief destination for South American wools. Liverpool rivals London in the trade in low wools and receives the bulk of the clip of alpaca. Glasgow receives Cheviot and blackfaced wools, and, with Leith, is the depot for Scotland. Bradford, the primary market for tops, is the depository market of a large part of the British clip, and of imported wool shipped there to be sorted for home and foreign consumption. On the Continent, Amsterdam, Havre, Hamburg, Bremen, Antwerp, Genoa, and Marseilles are markets of importance, and Boston, Philadelphia, and New York the major wool trading centres in America.

The absence of any "futures" market is a significant feature of the wool trade in England. There are exchanges in three Continental countries where wool or tops of a standard grade can be bought or sold in unlimited quantities, and where transactions can be rounded off by the payment of differences instead of by the delivery of goods. Tops can be bought in England for delivery at future dates, and an arrangement for weekly or monthly deliveries to the spinner is part of the ordinary course of trade. Yarns are bought also on contract, the buyer bargaining for a specified quantity and

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ON A SHEEP FARM, AUSTRALIA

supplying particulars of his exact requirements later. The transaction is in goods, however, not in paper, and a delivery of goods is required.

There are conveniences in such a system as prevails almost universally in the sale of cotton. Futures can be used to remove the gambling element in transactions requiring long to complete. Prices are as liable to fall as to rise while wool is on the water in course of its long voyage from the producing countries to the manufacturing centres, and the importer is exposed to the risk of a loss which he cannot conveniently insure against or control. By selling paper " futures " of the same month that his cargo is due to arrive or to be sold, he safeguards himself. The loss on the actual sale is compensated by the gain on the nominal transaction made in the terminal market. He sells his wool at a lower rate than he reckoned on, but buys back his " bear " of futures at a lower price than that at which he sold and collects the difference in his favour. A spinner embarking on a contract to deliver yarn at distant dates exposes himself to a risk of an advance in the price of raw material, which he may or may not be able to cover by contracting with a maker of tops. The futures market offers him an opportunity of insurance. By buying paper futures at the price of the day against his requirement of material months ahead, he secures himself of a gain on the one hand approximately equal in amount to his loss upon the other.

The advantages are counterbalanced by drawbacks. The standardization of a grade of tops and the abolition of the need to take delivery, throw the market open to speculation by outsiders who have no technical knowledge of wool and no substantial stake in the industry. The standard contract top becomes a gambler's counter, and transactions take place which have no real relation

to the natural requirement of trade. The defenders of the system maintain that in the long run unlimited buying and selling tends to steady prices, but this is scarcely the industrial view. English spinners will have none of a system which they regard as favourable rather to the professional speculator than to the industrial user of wool. On the Continent it is complained by manufacturers that the exchange transactions cause a decline in the quality of tops and an over-production of inferior tops, made to suit Exchange requirements rather than the necessities of industry. For these effects the rules of the exchanges and the standard type adopted may be partly answerable. The graver objections are that terminal dealings disturb prices unduly, create an artificial dearness, and lend an undesired aid to the finance of large speculations.

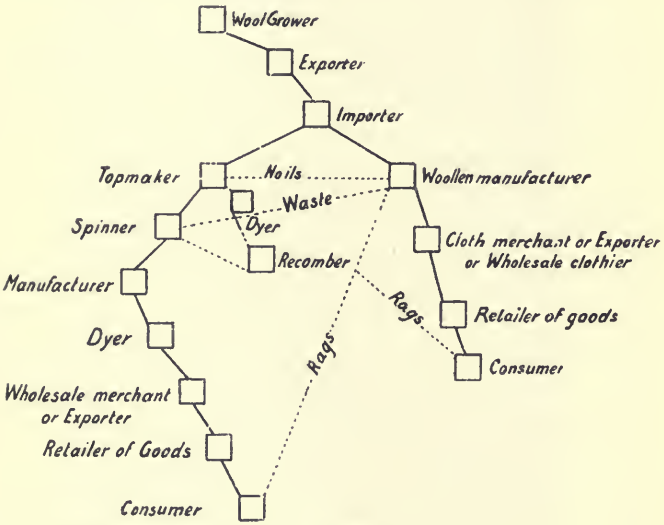
While the Continental quotations are far from being a perfect index to the future of the wool market, the prices are not disregarded in summing up the market situation at any given time. Reduction to a common standard makes comparison relatively easy, whereas comparisons between prices of raw wools may be seriously misleading to those who have not seen the particular lots, or are not in a position to appreciate their peculiar merits and defects. It is the custom, therefore, of brokers and market reporters to deal rather in percentages than in definite prices. " Merino grease sells at an advance of 5 per cent as compared with the close of the last series of sales "—write a firm of London brokers—" Scoureds show scarcely any advance. Crossbreds are 5 per cent dearer, the finer lots showing the advance most. Capes are fully up to last sales." The method lends itself to dispute, and eminent firms are found varying in their opinion as to whether the rise is really only $7\frac{1}{2}$ or as much as 10 per cent, but it has

conveniences and cannot be superseded without reducing the wools compared to some common denominator.

It is the settled policy of those who handle wool in this country to make participation by outsiders difficult rather than easy, and to leave to the buyer the responsibility of forming his own judgment. The "guaranteed yield" system on which South American wools are sometimes bought is a foreign innovation, devised primarily for the convenience of the Continental buyers, but now availed of by English firms. The South American wool exporters submit samples, quoting a price per lb. representing the net price of the scoured clean wool, i.e. after the removal of all grease and dirt. On the arrival of the bales the importer examines them and declares whether he accepts them as a good delivery or demands a test. In the latter event fifteen bales, or ten in every 100, are sent for sorting, scouring, and combing to some independent establishment agreed upon mutually. The buyer, in demanding the guarantee, submits to pay an extra charge of 1 per cent. upon the gross value of the invoice. Should the tests show a deficit the seller is bound to make the amount good, and if it should prove that the yield is better than that of the contract the buyer has to pay the seller the difference. The 1 per cent. charge ensures that the seller should not be held answerable for any underyield within that limit, and restrains the buyer from making vexatious claims.

Once out of the port-warehouse and on its way to the industrial centres, the wool has entered definitely upon its manufacturing career, and as much of it as is bought for English worsted purposes is sent to Bradford by rail and boat there to be sorted and blended with other wools for combing. The principal purchasers are the topmakers, who buy wool raw and sell wool combed, and shunt the by-product noils down a side

path. The topmaker's wool goes to his own combing shed, or to that of a commission comber who receives a fixed charge per lb. for his services. The tops pass eventually to a spinner, perhaps being dyed and re-combed on the way. The spinner having converted the tops into yarn according to his orders from customers,



THE COURSE FOLLOWED BY WOOL IN ITS MANUFACTURE

the yarn proceeds to the manufacturer to be converted into cloth. The cloth goes to the dyer and finisher, and finally to the merchant, after it has been mended and freed from defects. The merchant in about half the cases is a shipper or supplier of merchants or importers abroad, who in turn are the fountain of supplies to smaller traders, by whom at length the manufactured article is put into stock. The merchant may be a

home-trader, a supplier to tailors or drapers ; or, again, the destination may not be a warehouse but a wholesale clothing factory. The list, if long, is not so complicated as the manufacturing path some wool pursues, and the transit of half the world made by the raw material is completed in more than a few instances by the transit of the other half by the finished goods.

The noils, it has been said, have been shunted down a separate path, usually into the hands of a dealer who deals also in the wastes or by-products created in spinning worsted. These are the natural food of the carded woollen trade, British or foreign, and go to make blankets or serges or tweeds, not improbably in conjunction with that other recovered material known opprobriously as shoddy, and in the trade more usually referred to as waste. The course followed by woollen rags on their paths back to the mills is not less adventurous than that taken by virgin wool.

Collected from the clothing factory or tailor's shop, or from the housewife in exchange for crockery and toys, rags destined for remanufacture start on the tortuous course which leads to Dewsbury—the metropolis for rags. There the rag auctions are held, and there, or near there, some 1,500 tons a week of home and foreign rags are reduced once more to spinnable fibre. The cast-off garment passes from the hawker to the small marine store dealer, who places it with garments of a similar kind. From his hands the rags go to those of a larger dealer, possibly in the capital or port, to be reclassified according to quality or colour, or to be torn apart at the seams and to have the linings and pocketings removed. The dealer parts with them commonly to a shipper or merchant, to undergo further sorting and handling and reduction to a standard, to be packed and sent on consignment to the sales.

A WOOL BARGE ON THE RIVER MURRAY, VICTORIA, TAKING WOOL TO THE SEA

There the bales are sold to the assembled buyers to be taken away and sorted more, to be dried and beaten free from dust by a machine, to be "seamed" by girls, or possibly to have the remnant of cotton removed by carbonization in acid. Some of them are "stripped" or decolorized and dyed afresh. All that are fit for another period of service are passed through the "devil" or rag-pulling machine. The rags are nipped by rollers and shredded by revolving hardened steel teeth into their constituent fibres. The conversion of the waste articles, rags, into new, handsome, and serviceable cloth is not the least wonderful achievement of industry. There go to the work no less pains, skill, and taste than are employed in the production of other fabrics, and the ingenuity is, perhaps, greater than in making articles of more showiness from materials more promising in the inception. Certainly the operation arouses some jealousies. There are farmers who can never be persuaded that man ought to be allowed to make or wear cloth other than from new wool: and manufacturers who resent the competition of the cheap goods made from waste.

A host of misconceptions surround the word shoddy, first of which is the notion that use of the material is unnecessary and even immoral. As to this it may be pointed out that the world wants warmth, and that the annual supply of virgin wool is limited. The supply is enough, upon Mr. Samuel S. Dale's calculation, to provide about 13 ounces of wool per head of the population outside the tropics; in short about enough to give each person as much cloth as would make a summer suit once in every five years. Wool, it is true, is weakened and shortened and deprived of some of its fine scales by its manufacture, remanufacture, and incidental washings and wear, but shoddy is not necessarily

poor stuff. There are qualities of it as distinct as qualities among new wool, and it is undeniable that the best rag wool is superior in all respects to many wools that have not undergone a previous period of service.

Shoddy is strictly the name of long fibres recovered from knitted fabrics, or from long-fibred and loosely compacted cloths. Mungo is the name for short fibre produced by grinding the harder cloths, but there is a place for short fibre as well as for long, and mungo is used not to the detriment of woollens, but for their improvement. With no mungo, there are handsome and durable milled cloths which could not be produced at all. And were the rag reserves, to the crying shame of the world, to be wasted, the upshot could only be that the many who could not pay for new wool must be clothed much worse. One had as well waste old metals as old wool; the consequences to the public at large would probably be less serious.

CHAPTER IV

COMBING AND SPINNING

In a reference already made to the scouring and drying done in preparing wool for the wool comb, nothing was said of the imperative necessity of soft water, pure soap, gentle alkali, and the avoidance of excess of heat whether in washing or drying. They are matters that cannot be overlooked by the man who is doing the work. Wool is easily injured in scouring, and the work is done very much better by some than others. It may be asked why not scour abroad, why pay freight on a bulk of greasy wool consisting half of impurity? The answer is that spinners do not wish their wool to be scoured except in the best manner, and in any case do not wish to have it press-packed and tight-bound for months after the operation. Except in exceptional cases the excess freight is the less of two evils, and where the worsted user has his way the wool is not scoured at the point of production.

The wool is scoured at the combing-shed as part of the series of operations which turns wool into tops, and before combing the wool is opened preparatorily by one of two machines. The longest wools, exceeding seven inches in staple, are passed through the machines known as the "preparer gill boxes," into which wool is fed through rollers by means of travelling aprons. Within the box the wool fibres are stroked and humoured into a straight fore-and-aft position by travelling combs or "fallers." The latter are steel bars studded with steel pins on their upper surface, travelling faster than the wool, and propelled by a worm motion. At the

end of its traverse each faller falls or sinks to the bottom of the box, is worked backwards to the starting-point, and raised by the action of a cam to the upper screw. There is a succession of such " sheeter " boxes adjusted to perfect the ordering of the fibres and deliver the wool in a sheet or film. The sheet passes into other " boxes " designed to comb the wool further, draw the fibres lengthwise upon themselves and deliver not a sheet but a " sliver " or continuous untwisted rope of wool.

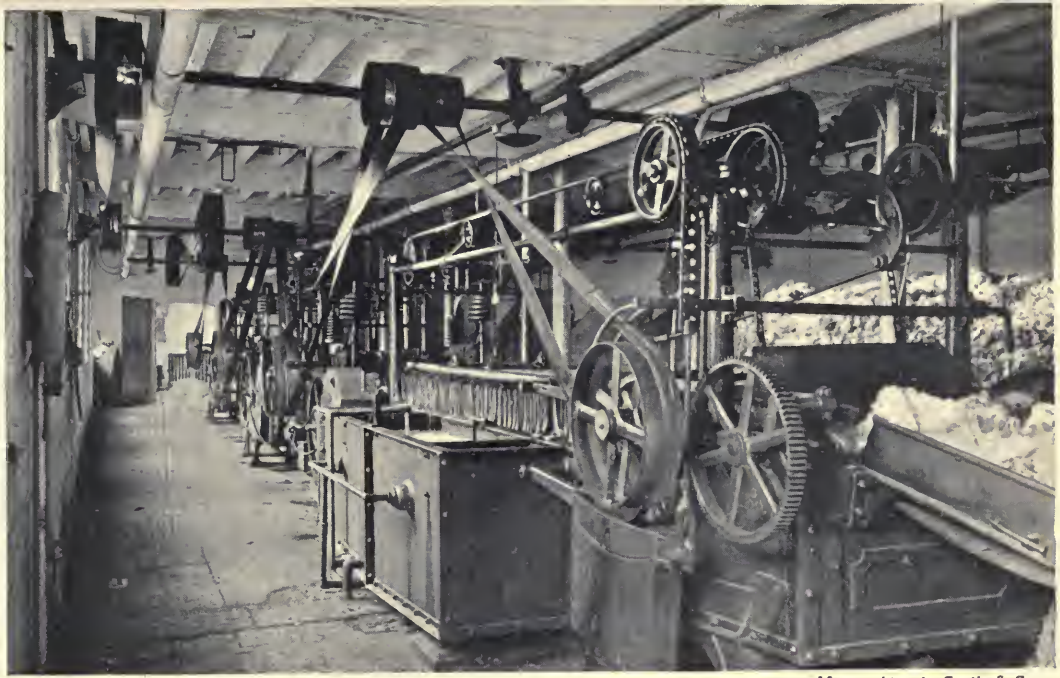
The alternative is to pass the wool through the worsted carding engine, and accordingly as the wool receives one or the other treatment its tops are known as " prepared " or " carded." The qualification denotes a difference in the length of the fibre used as well as difference of treatment. The carding engine is a machine of many cylinders, furnished with a myriad of fine wire teeth. There are main cylinders or " swifts " whose prime purpose is to carry the wool forward, and at different places, with different teeth and working at different speeds and in different directions, there are minor cylinders working upon the circumference of the swifts. The teeth tease and open the wool, and form it into a veil which is divided finally into continuous slivers ready for entrance into the wool comb. Crushing rollers, or an arrangement of beaters, are set to remove so far as may be, the tenacious burr weeds gathered from the pastures. The preparatory treatment, the breaking of the burrs and of the nodules of dirt not removed entirely in the first scouring, involves in cases the necessity of backwashing. The name has a history dating from the time where the hand-comber had to take his tops back to the spinning factory and wash them there by hand before recombing them for final delivery. The modern backwasher is a mechanical contrivance of troughs of suds and mangle rollers for

squeezing, with steam-heated drying cylinders behind. After backwashing comes the oiling of the wool.

Scouring takes away much, and backwashing takes away more, of the fat natural to wool and, deprived of its grease, wool is at once more harsh and more brittle. The best olive oil is the chosen lubricant for diminishing breakage during the operation of combing as being that which is most readily and completely removable later, leaving the wool in the best condition in the end. Combing without oil is done upon wools intended for dyeing to light shades, where the least trace of discoloration is serious, but oil-combing is the rule, and is done on a scale which gives combers the liveliest interest in the olive-oil market.

Wool containing too much vegetable matter to be cleared by mechanical action alone can be given a chemical treatment, called "carbonizing," because in course of it the woody tissues are reduced to carbon or hydrocellulose. In modern practice, the burr-infested wool is impregnated with acid in travelling through the trough of a machine like that used in wool-scouring. The weed is charred and the wool dried in passing through a hot-air chamber, and in this state the vegetable matter is readily crushed to dust between fluted rollers and is removed in a succeeding machine. The acid in the wool is neutralized by washing in plain water and in an alkaline solution, and the wool is again dried. Under sufficiently skilled handling, the processes leave the wool unimpaired in softness and colour, although they are capable of doing harm to it.

The hand combers of two generations ago used oil and used heat, and the machine combers need both in their work. The hand comber combed by means of steel pins, and steel pins are still the means in use. The hand-worker used something like a rake furnished with



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WOOL SCOURING

long pins arranged in rows of descending length. A similar rake was attached to a post, and using a circular sweep the long fibres were gradually tickled away from one comb to another, and were worked from comb to comb in turn, the noil finally remaining near the roots of the teeth. The Noble comb, which is the type most in use to-day, works also with a circular motion, but the motion is horizontal not vertical, and the pins are short ones fixed in revolving circular plates. The wool is dabbed into teeth set upright in a large or main circle, and is worked upon by the pins set in the minor circles revolving upon the face of the larger and in the same direction. The long wool is drawn away by that circle which has gained the firmest hold, and so formed into a projecting fringe which is automatically drawn off, while the remnant of fibre too short to be caught up by the moving circles is left behind. The continuous taking-off forms the wool into a continuous twistless sliver, and the sliver is perfected by passage through a series of "finisher boxes" resembling the preparer boxes with which the process begins, but adjusted to work more finely. The machines are designed to blend and intermix the slivers thoroughly, and improve the uniformity of the top, finally turning off a finished sliver of which each yard has an equal and determined weight. The product is the "top" that is purchased by the spinner.

Some idea of the economy of working may be got from the information that the cost of performing this long round of delicate and difficult operations involving the use of so much intricate and expensive machinery is—according to the class of wool—from 3⅜d. to 7¼d. a pound of finished top.

To become yarn fit for weaving or knitting, this top has to be attenuated more. The fibres have to

be drawn over each other until the root of one is nearer to the top of another, and the whole has to be bound together by receiving twist. These are the operations performed by the worsted spinner who performs them gradually by successive steps nicely calculated to the determined end. The yarn, when finished, has to measure a definite number of yards to the pound, to be free from unduly thick or thin places, and have a certain uniform strength. It has to maintain the reputation of the spinner, give no cause for claims for damages on account of spoilt cloth and still be produced continuously, steadily, and at astonishingly little expense. This result is unattainable without incessant attention to an infinitude of small details, and is arrived at by a close specialization of function. A worsted spinner, except under circumstances of pressure, stands fast by his own qualities of material and his own range of "counts," finding his best chances of profit in the branch of business best known to him, and for which his machinery is most adapted.

When housewives spun with the aid of the hand-wheel, they divided their operation. First came the "drawing," done for the purpose of producing a loose and lightly-twisted cord of wool called "roving." Actual spinning followed when the roving was farther drawn by finger and thumb and twisted and wound upon a pirn. In worsted, this separation of drawing and spinning into two operations persists, and the spinner goes to work to produce a perfect roving. The comber's top is "gilled" in machines differing only in fineness from the preparer and finisher boxes used in combing. After a suitable number of passages have been made by the fine steel pins the gilled tops with their fibres parallel and point-device, enter upon the drawing proper. The drawing boxes, like the preparer, finisher, and gilling

boxes, have pairs of leather-covered rollers at each end, but are not furnished with teeth or "fallers." Inside are other rollers acting as carriers or supports.

The back and front rollers do the work, the back ones carrying the sliver in, and the front ones passing the sliver out. The front rollers are set to travel at a higher speed than their fellows; they discharge sliver faster than it arrives, and draw the sliver finer by passing out a greater length than comes in. There is a sequence of these boxes, and in issuing from each of them the sliver is wound upon large bobbins and carried to the next. The front and back rollers are adjusted at such a distance apart that they should not break the longest fibres, and not leave the shorter ones unsupported for too great a while. The slivers are doubled and redoubled. At the first box six ends of sliver may be put in together and drawn into one, and in successive boxes 6, 5, 4, and 2 ends; which is to say, the material is doubled $36 \times 25 \times 16 \times 4 = 5{,}760$ times, which is relatively a low number. Botany slivers are doubled in this cumulative way hundreds of thousands of times, to secure a perfect uniformity of mixture and hence an equal yarn of whatever fineness and one capable of producing a faultlessly even and unbroken surface upon the face of the cloth.

Spinning is only the completion of a work that has been three-parts done. It rests to draw or draft the roving still finer, put in twist to bind the fibres together and wind up the spun thread in some convenient form. The further drafting is done again by rollers set to exercise drag upon the passing roving, and these are the first working parts of all spinning frames. The second essential is the arrangement for twisting, which is not the same in all frames. Three types of frames are used in worsted—the flyer, cap, and ring.

The flyer frame is useful for thick counts and for all qualities, and it produces a smooth yarn free from "beard" or surface hairs, but cannot be run at so high a speed as the cap spindle. The ring frame is used more commonly in doubling than spinning. A pair of arms rotating round the bobbin give the flyer frame its name, and these move faster than the bobbin itself, carrying the yarn in an eye at the lower extremity of one arm. The bobbin winds, and the flyer puts in the twist, giving in accordance with its speed and that of the bobbin a regulated number of turns per inch. The less the twist the greater the off-turn.

Cap-spinning frames are used for Botany, but are unsuitable for rebellious material, and in them the spindles do not revolve. Motion is given to the bobbin by a tube around which the bobbin fits. The cap of steel, a little larger than the head of the bobbin, rests stationary upon the spindle head, serving as a guide to the yarn and providing a relatively frictionless surface. The bobbin revolves inside the cap, and the number of revolutions it makes during the period of time in which the delivery rollers turn off one inch determines the number of turns per inch (i.e. the amount of twist) in the yarn.

In the ring frame spindle and bobbin revolve together, and a light drag is put upon the thread by a ring of bent wire known as the "traveller," which is drawn round the flange of an annular opening in a rail. The opening in the rail surrounds the bobbin, and a gentle up and down motion imparted to the rail guides and equally distributes the yarn over the bobbin's whole length.

There are important differences in the speeds at which the several kinds of frames can be run, and this affects the production. At a speed higher than 2,500 revolutions a minute, the vibration in flyer-spinning

is injurious to the yarn, but the flyer is used in general for all counts up to 24's. The cap frame driven at nearly three times the speed, or the ring frame, are used for yarns of greater fineness.

The spinning frame produces " singles " or yarn of a single strand, but the greater part of worsted is used in twofold and the operation of combing together two or more singles into a compound thread is spoken of as doubling. The doubling is effected upon a machine which is virtually a spinning frame upon which there are no drafting rollers. The singles are brought together and bound by twisting in the direction opposite to that in the single threads. The yarn leaves the spinner's hands after being wound into the form required, and the machinery used in rewinding from the spinning bobbins has been the subject of new attention and ingenuity. The outsider is most familiar with yarn in hanks or skeins, but to meet varying trade needs, yarn is wound conically upon spools or is crossed and recrossed on other tubes into the shape known expressively as " cheeses." Again, it is wound into bottle-shape upon bobbins, but for weaving purposes its principal appearance is in one of two forms : on spools for use as weft, and on beams for use as warp. The beam is a giant bobbin the width of the loom, and the necessary number of threads to form the warp of the cloth are wound parallel upon it in the machine known as the warping-mill.

The operations involve expensive machinery but they can be done with great economy. In pre-war times a spinner would convert tops into yarn at a charge of about 3d. per lb. in such relatively thick counts as twofold 24's, or for 9d. per lb. would spin as fine as 2/60's or, say, nine and a half miles per lb. At twice the price the operation is upon the whole less profitable to-day.

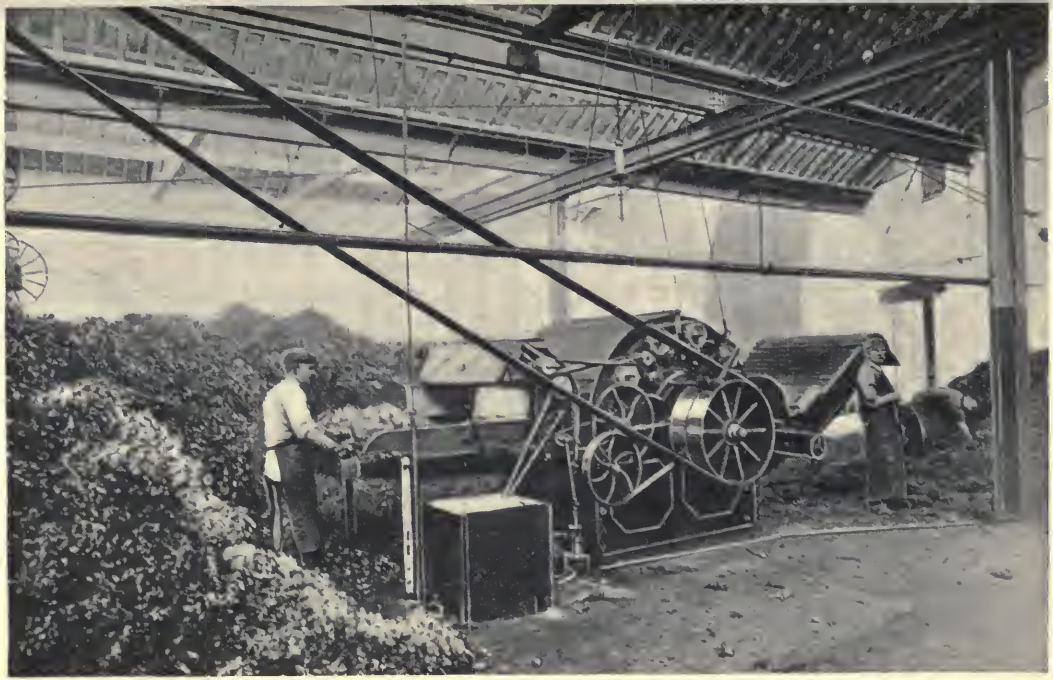
Exactness of count is reached with marvellously little deviation, and in the yarn contract rules made by the Bradford Chamber of Commerce there is provided a margin of not more than 1 per cent. This allowance is made not to cover error, but as a provision against the shrinkage to which yarns, like cloth, are liable. Shrinkage apart, it is required that hanks drawn from a bundle shall average 560 yards per lb. This exactitude in the matter of length in conjunction with the undeviating regularity in point of diameter, is the best evidence of the delicacy and care requisite in worsted spinning.

CHAPTER V

CARDS AND MULES

WORSTED begins by rejecting the short fibres and selecting from the long those that are most uniform in length and diameter. Worsted processes aim sedulously at preserving the parallelism of the constituent filaments, and this feature the woollen processes consistently avoid. The woollen manufacturer's aim is the production of a yarn in which the fibres are mixed at all angles and in which the longer hold and support the short. There is no combing and all the stroking and teasing out is done with a different aim.

The raw material is opened by means gentle or severe according to its nature or state, and whether the opening out is preceded by scouring or dyeing depends upon the circumstances of the case. The typical opening machine is the " willey," in which a cylinder of three or four feet diameter, garnished with steel hooks, carries the material round to be operated upon by three cylinders furnished similarly and working in the opposing direction. The willey in its main lines is typical of the machines which follow it and have supplanted the flat hand-cards of the housewife. These instruments, shaped like fire-shovels or curry combs, were bristled with pins of spring wire set in a foundation of leather and were manipulated like hand brushes to work the material into a spongy pad from which a sliver reducible upon the spinning wheel to a continuous roving was drawn by hand. The teeth remain but are mounted on rollers and not upon flats. The hooks of the willey are succeeded in the carding machines by a card-clothing of pins, graduated in fineness and sharpness according to the work they



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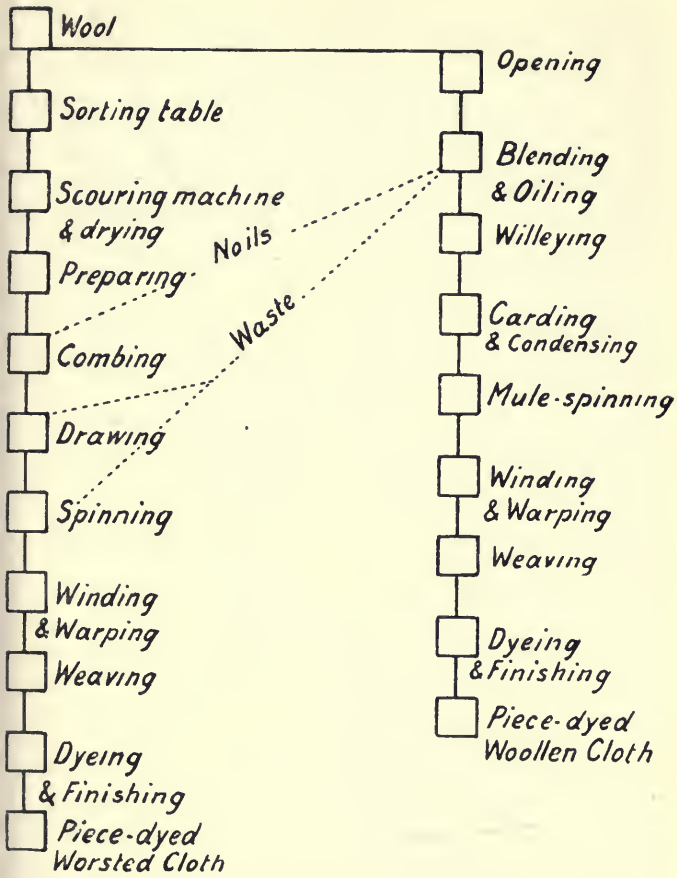
IN THE WILLEY HOUSE

have to do, and adjusted to turn out continuously a smooth and regular supply of sliver.

The materials used in making a woollen yarn are first blended, layer upon layer, in a stack to secure a preliminary mixture of the several sorts in approximately equal proportions. In course of stacking the layers are oiled to lubricate the fibre and the material passes to the carding-engines, of which three are used ; the first, or " scribbler," being for the rougher work. Wool, weighed out by an automatic device for securing a regular even feeding, is received on a feed-apron and taken up by the " licker-in." The wool is removed by a neighbouring roller and delivered to the fast-moving main cylinder or " swift." The wool travels into the slow-moving teeth of a " worker " roller turning in the opposite direction, is stripped and passed to another worker roller and back to the swift. The wool is lifted lightly from the pins of the main cylinder by the intersecting pins of the " fancy " and is finally cleared by a " doffer " and passes on to a second, third, or fourth swift.

The " scribbler " feeds the " intermediate " card, a machine working in the same manner as the scribbler but furnished with finer teeth adapted for use upon material that has already been worked upon. This third machine of the set is still more thorough in its action and has the function of completing the work of the other two. It is known as the " condenser," for its final operation is to draw together the veil of fibres distributed over the full width of the rollers and to divide and condense the web into slivers. The three machines are in series, the material passing from the first to the second and third continuously. The woollen objective is the production of yarn with fibres lying within it at all angles, but the card teeth tend to draw the fibres straight. To defeat this effect, in passing from



THE ORDER AND SUCCESSION OF THE MANUFACTURING PROCESSES

one card to the next, the fibres are delivered to the succeeding machine in a direction at right-angles to that in which they came out of the last. The slivers issuing from the condenser are taken up on bobbins in readiness for spinning upon the mule.

The spinning mule with its round of complex motions is the most fascinating of machines to watch. More exactly than the worsted-spinning frames, it reproduces the motions of the spinster at the hand wheel. She attenuated her thread by drawing away her hand from the spindles. In the mule the condensed sliver is drawn thinner by the outward motion of a carriage bearing the spindles which retreats bodily on wheels and rails away from the rollers that pay out the sliver. Automatically, the spindles by revolving apply a slight twist during the outward run and automatically the supply of sliver stops. The carriage continues the outward run and the spindles continue to put in twist. The carriage stops, the spindles double their speed to put in more twist, and the carriage moves homewards a little way. The twisting stops, the mule backs off and returns a few inches, a taut wire comes into action to maintain the tension on the 400 threads. The carriage completes its return home to the face of the rollers with the 400 spindles energetically winding up the yarn that has been drawn and spun during the operation.

The outcome of the woollen operation is a yarn inferior in tensile strength to the product of the worsted process but greatly superior in felting properties. The fibres crossing and recrossing in the yarn, are in the positions in which the minute serrations, discoverable with a microscope upon the edges of all wools, are best able to interlock—as they are made to do in cloth finishing. The yarn is softer and bulkier than worsted and capable of producing a greater variety of effects in cloth.

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SPINNING MULE AT WORK

Yarn is not, on the whole, produced from wool more cheaply by card and mule than by comb and frame, but it may be made of cheaper materials and hence be cheaper in the end. The worsted spinner is tied to new wool and long wool; the woollen spinner is free to use short wool or to suit his purposes by mixing-in of woollen wastes and cotton. Worsted yarn fluctuates in price in sympathy with the wool and top market. By reason of the wider choice of materials prices of woollen yarn change relatively seldom. And this freedom of choice, introducing greater possibilities of complexity, brings also more opportunities for the exercise of skill.

More than a little ingenuity is used in compounding a serviceable worsted top for the market and bringing it in at a low price. The topmaker considers length, softness, colour, and all that goes to make the characteristic described vaguely as quality. He intermixes fleece wools from different sources according to their suitability and price, and possibly adds skin wool and odds and ends, but his freedom is restricted in contrast with that of the woollen carder. In blending and carding woollens profits are lost or made. The blend determines the price and the output from the cards governs the production of the whole of the rest of the mill. The successful carder exhibits his skill in "getting weight back," which is to say avoiding loss of material in working; by putting through a maximum quantity of wool per day and producing at the same time a homogeneous mixture from which the spinner can turn out a yarn even in thickness and uniform in strength. The number of the carding machines is the measure of the productive power woollen mill, and in comparing sizes of mills it is customary to count not looms or spindles but "sets"—sets of cards with their appurtenants.

CHAPTER VI

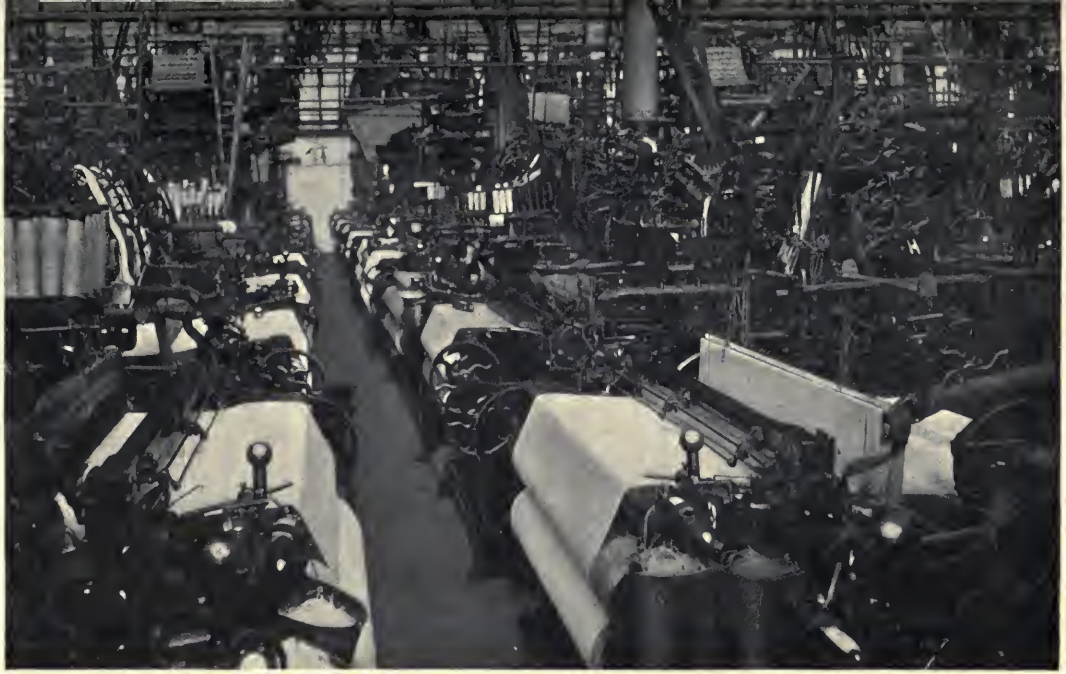
CLOTH MAKING

KNITTING has enormously developed, partly at the expense of woven goods. The knitted undergarment has replaced the flannel one, and when the season turns it is the knitted garments rather than the woven ones that are changed. Withal weaving is the main outlet for worsted and woollen yarn, and the loom in its main essentials is the same in principle as that which Eastern craftsmen have improvised from time immemorial with a few sticks and an end or two of rope. A means of holding the warp and of parting its threads, a means of throwing the weft across the " shed " formed when the warp threads are lifted, and a means of beating up the weft when woven, are the features of all looms of all times.

Handlooms for woollens were common up to fifty years ago in England, where the handloom survives as an instrument for weaving pattern lengths in the mill and as a domestic machine in cottage industry. The power loom differs from it in being driven by power instead of by hand or foot, and again, in the capacity of output and the greater automatism of its motions. The warp is let off in the modern loom automatically from the beam upon which it has been wound by the spinner. The cloth is automatically taken up as it is woven, and the shafts of healds controlling the several divisions of the warp threads lift in obedience to the action of cams or in response to a barrel-organ method of control whereby particular sets of threads are caused to lift at the proper moment by the action of pegs

adjusted to engage with the holes punctured in leaves of metal or pieces of cardboard. The power loom in use in the woollen and worsted trades does not differ significantly in mechanism from the machine used to weave any other yarns into fabrics of similar width, weight and complexity.

As is well recognized, wool fabrics have the faculty of shrinking, and the processes of cloth finishing are adapted to make them shrink in width and in length, or both. Accordingly, cloths are commonly "set" in the loom materially wider than the width to which they are to be reduced for sale by the cloth finisher. The wide looms used in producing woollens of 54–60 in. width are commonly capable of weaving up to 90 in. wide and worsteds intended ultimately to be about 56 in. wide are woven in looms with a capacity of 76 in. The speed of the loom is measured by the number of "picks" or crossings made per minute, and the speed is naturally lower in wide looms than in the 40 in. or narrow looms where the distance to be traversed by the shuttle is halved. The speed is to some extent adjustable and is reduced upon looms weaving soft woollen wefts such as are liable to breakage, while the speed is increased where strong worsted wefts are employed. The complexity of the pattern is also a determining factor. All weaving is a matter of the intersection of one set of threads with another, and it is apparent that changing of the lift of the warp threads or of the shuttling apparatus necessary to carry wefts of a separate colour occupies time. In plain narrow looms weaving may proceed at some such speed as 200 picks a minute, but in weaving wide fabrics the rate is at least halved and may be no more than one-third. The picks per inch determine the rate of production and their number varies with the class of cloth made. In the



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SECTION OF A WEAVING SHED

coarsest woollens there are some such number of weft threads as twenty per inch and in the ultra-finest worsteds 200 or over. The difference denotes extreme variations in the speed and the cost of weaving and the figures are to be understood as extremes. A manufacturer bases his calculation upon a certain average, and some sixty to seventy picks per inch may be taken as the mean.

The more intricate the work the greater the strain upon the weaver, and the best worsted goods are made with one weaver superintending one loom. Two ordinary looms can be tended by one weaver in weaving common goods and with a more elaborate division of function one weaver may tend a dozen of the so-called automatic looms. The automatic loom is described more precisely as a self-shuttling loom, in which the shuttles are replenished as the work proceeds. In ordinary weaving one of the recurrent duties of the weaver is to insert new weft as the supplies within the shuttle are exhausted. The automatic loom replaces exhausted shuttles by full ones obtained from a prepared supply without human intervention, and it is a machine of growing importance now that plain cloths can be woven with weft from alternate shuttles. Wool goods are, upon the whole, expensive ones in which a higher standard of woven perfection is required than in cheap cottons. A very small difference in the weft contained in successive shuttles is apparent in plain goods and these differences are accentuated when the weft from one bobbin is woven continuously back and forth across the piece. The defect stands out by contrast with the few inches of cloth woven from the preceding bobbin and the following one. An arrangement which alternates weft from one bobbin with weft from another, thread and thread, breaks the continuity of the

defects and in doing so renders them comparatively harmless. The automatic loom becomes a more serviceable instrument for weaving self-coloured goods, and it is prevented from continuing to produce faulty work by devices for bringing the machine instantly to a standstill upon the breakage of any thread.

Varieties of pattern may be produced in warping the threads in a manner which alternates those of one colour or nature with another, and the gearing of the loom causes threads of one or another to be lifted as required. Changes of colour in the weft are effected by a system of multiple shuttles and by bringing the shuttle containing yarn of the requisite colour at the right instant. The drop-box loom in which the shuttles are arranged in vertical series, one above another, and the circular box loom in which the shuttles are set on the surface of a cylinder, are the two machines for making patterns by transverse threads of different colour or kind. Small simple changes are woven in the tappet looms in which the warp threads are lifted in rotation by the action of cams. Small figured patterns are produced upon the dobby loom, a modification of the Jacquard which permits of the rapid weaving of patterns requiring a large number of shafts. Large figures like the floral and geometric forms seen in some dress goods and upholstery fabrics are produced upon the Jacquard, a loom attachment for securing a greater liberty of action than can be got by lifting the warp threads through the medium of heald shafts. The three types of looms give varying power in the selection of the elements that are to be brought to the surface of the cloth, and each type is susceptible of adjustments enabling innumerable patterns to be woven.

Following the weaving comes the mending, when, with needle and short length of yarn, the girl mender

remedies the deficiencies left by the loom. Mending and burling cost as much as weaving in the production of some goods produced at high speed, and sometimes very much more. The mender replaces missing threads and repairs damages so far as is practicable. The burler removes with tweezers the stray filaments of foreign fibres such as have refused in the dye bath to accept the same dye as the wool. Strips of weed gathered in the pastures, or fibres of jute rubbed from the inside of woolbags become incorporated with the wool and pass through the processes without detection to appear as expensive blemishes at last on the face of a fine worsted fabric.

Cloth, as it leaves the loom, is short of at least half the attractions that cloth has in wear. It is open in texture, redolent of oil, somewhat fuzzy on the surface, and even if dyed in the yarn or wool is duller in appearance than finished cloth. Wool is dyed in any of four stages. Loose scoured wool is dyed for the use of the carded woollen manufacturers. Worsted tops or " slubbing " is dyed for the spinner of mixture coloured worsted yarn. Yarn is dyed for fancy cloths either in warp form or in hanks. More is dyed after weaving and the cloth is described then as piece-dyed. Cloth undyed is " in the grey " and the sight of it gives little enough idea of what dyer and finisher between them will make of it. The woollen manufacturer usually finishes, although he does not always dye, his own fabrics, for woollens in especial are plastic material, requiring sympathetic treatment to obtain the exact result desired out of the large number of results possible. The worsted manufacturer delegates both functions ordinarily to a commission dyer and finisher, who carries on the process on a relatively large scale.

The routine of piece-dyeing and finishing varies in its

broader details with the circumstances, and in its smaller details varies in accordance with the result required. First, the grey cloth is relieved of the oil used by the comber or carder and this is done in laundry fashion. Pieces stitched head to tail, forming a band perhaps some hundreds of yards long, are under one system of treatment run through a warm soap solution in the " dolly." From the trough of suds the cloth is passed and repassed through massive wooden and squeezing rollers for as long as two or three hours. " Milling " follows, an operation once performed by the feet and later by the fulling " stocks." The process aims at felting together the loose structure formed in the loom, and woollens are made with a view to a close condensation at this stage. The fabric gains in substance what it loses in width and length and the treatment may be of any severity. In the fulling stocks ponderous mallet heads, actuated like trip hammers, are raised and left to fall alternately upon the cloth as it lies in a lump in a trough or basin. With every blow the cloth is moved a little and all parts of it in turn are hammered equally. Rollers replace the hammer in the milling machine and reduce the cloth in width while compression in a funnel-shaped passage contracts the cloth in length. Heat, alkali, and pressure in combination cause wool to shrink and all three factors are present. The minute scales or serrations lock and interlock, the curly fibres creep together more closely, and become more or less felted or matted. In worsted, where the opportunity of felting is less, the fibres burst loose by the treatment appear on the surface and form a loose nap or " cover " upon the face.

Wool dyeing is done with boiling water and before the fabric can safely be sent to the dyeing machine it must be " set " to prevent an unequal shrinkage that might cause crimped or cockled patches. The operation

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is called " crabbing " and is done on a relatively simple machine. The cloth is wound carefully at full-width upon a roller and led through troughs of hot water and cold alternately to a further roller, hollow and perforated, on which the cloth is rewound and boiled or steamed. Dyeing follows in a vessel heated by steam-jets and fitted with rollers against which the cloth runs. The detail of the treatment varies with the dyestuffs used and various of them require more than one operation to dye and fix the colour upon the fibre. Dyeing is followed by washing to remove loose colour, and by tentering to preserve the width of the cloth. The lists or edges are brushed down upon parallel rows of pins set in the " tentering " machine at a distance apart equal to the width the cloth is to have when finished. The fabric is " dewed " or moistened to restore the moisture proper to its nature. Its surface is raised or scratched, if need be, either with a drum set with teazles imported from France for the purpose or with steel pins set on rollers. These thistle heads or wires raise a pile upon the surface which the cutting-machine reduces or removes. The cutting blades are set spirally as in a lawn mower and are adjustable delicately to the work. The finishing ends ordinarily with pressing. The cloth, thrown into equal folds, plaits, or " cuttles " by machine, is interleaved with cardboard presspapers. Hot and heavy iron plates from a steam-oven are placed between each piece in the upright pile in which the goods are stacked in a hydraulic press. The pressure is applied and maintained for a time and a power proportionate to the effect sought or the kind of goods treated. The operation is called " hand-pressing " as it involves a considerable amount of handling of the goods, and it is distinguishable from the less efficacious " rotary pressing " in which the goods run continuously through a

machine in which they are heated by steam and pressed hydraulically while moving.

Pressing consolidates and smartens the appearance of the cloth, giving it in some circumstances more glaze than is required. The removal of this surplus finish, and the reduction of the cloth to a state in which it will not shrink in wear, is the function of the " London shrinker." The cloth is wetted by the shrinker between moist layers of canvas and hung up to dry, or it is mechanically wetted and dried without heat.

An alternative to London shrinking is applied as the final operation to large quantities of cloth. The fabric is rainproofed by a process which, while leaving the cloth porous, improves its resistance to wet. The regular method involves two steps. The cloth is impregnated thoroughly with a solution of acetate of alumina, a chemical highly soluble in water and so not in itself a sufficient protection against rain. In course of drying, or after drying, the cloth is coated with a fine film of hard wax, applied either in a melted state or by dry friction. The wax, in addition to acting as a waterproofing substance on its own account, assists to lock the soluble acetate within the fibre. The process is very much cheaper than the system of waterproofing by means of rubber. It is effected in one passage through a continuous machine and is completed by pressing the goods to restore the required degree of finish.

If the means employed in cloth finishing seem simple the effects produced are strikingly complex. The changes wrought in what might excusably be taken for a soiled sail-cloth in the first instance are conspicuous to the eye, but the finisher has to satisfy another of the senses. The " handle " of the goods must be neither too sharp nor too soft. The weight per running yard

must be right and there has to be neither too much nor too little nap or cover. The design of the cloth has not to be over-distinct nor yet too much broken, and between wrong and right, between what any bungler can do and the complete cloth finisher can do with the same means and material, there is a gulf wider than might be believed. In truth, the work calls for the nicest apprehension and the most delicate judgment. The whole matter is one of hairbreadths, and by signs incomprehensible to the layman, the practised finisher brings the cycle of processes to a perfect culmination.

The processes employed in bringing, for example, mohair and worsted and cotton linings to the full height of their lustre are destructively severe. The finishing treatment designed to add to their appearance is conducted somewhat at the expense of strength of the goods. Improvements in obtaining not merely lustre, but permanence of lustre, come as the outcome of bold experiments involving often the ruin of hundreds of pounds worth of goods. Any marked failing in the finished result is visited by penalties that are always heavy. The goods if declined by the original customer may go a-begging in vain. If they have to be sold as "jobs" for the account of the dyer and finisher who has spoilt them, he is fortunate indeed to escape with a loss of not more than 50 per cent.

CHAPTER VII

THE NATURE OF CLOTH

As it presents itself to the practical manufacturer a given cloth represents, firstly, wool of a certain quality, yarn of a certain count, woven with a certain number of threads per inch and finished in a particular manner. The quality betrays itself at once to the experienced touch and the count of yarn can be inferred, judged by comparative test or ascertained with more certainty by delicate weighing. The weft and warp threads can be counted and there results a statement of particulars of which this is an example bearing on a light worsted fabric—

Warp.	Ends.	Sett.	Picks.	Weft.
2|32s	3002	52	56	1/24s

70 yds. warp, 63 yds. finished.
64 ins. wide, 58 ins. finished, 10-10½ oz. per yd.

The weight of the warp is found by multiplying the ends (3002) by the length (70) which gives as the product the total number of yards; this divided by the hanks per lb. (16 = ½ of 32) multiplied by the yards per hank (560) gives the weight of approximately 23½ lbs. per piece. The weight of weft is the balance required to make up the weight of the cloth in the grey state, from which an allowance of five per cent or so is to be allowed for loss in waste and shrinkage. The prices of the yarns being known, the cost of weaving being taken at the price paid in the district, and costs of dyeing, mending, and finishing added, the net cost of manufacture is obtained. The cost of all processes incidental to weaving is reckoned in the district from which the sample in

question comes at double the amount paid in wages to the weaver.

A hundred incidental considerations affect the value at any particular moment of any given sample of cloth. The price of raw material, the amount of stock on hand, the fashion in colour and design, or the season of year, will influence buyers in one direction or another. In the market sense cloth is worth what it will fetch, and in practice cloth to realize to the best purpose has to conform to the arbitrary limits which custom and competition set. It has to display certain superficial attractions, possess some solid qualities, and withstand comparison with any goods that might be used in its stead. No close familiarity with the operations of manufacturing is necessary in order to make a shrewd guess at the actual worth of a fabric. Were it otherwise, buyers would be less successful in beating sellers down. What is essential is that one should have certain powers of observation and a familiarity with the prices and characteristics of cloths of a similar kind.

The permanent features which lend value to cloth begin with the raw material of which it is made. The fineness of the yarn from which it is woven and the number of threads to the inch are other considerations of the same class. Some idea, however rough, can be gained by making a dissection, releasing and unravelling bits of yarn to judge of the length and fineness of the fibres, especially to see whether the yarn contains short stuff, and to note whether the thread is single or two-fold. There are tests which can be applied hastily to determine of what the material is made. If there is doubt whether a particular thread is wool at all, something is to be learnt by biting it. Wool is characteristically harsh and gritty between the teeth, and the differences of sensation can readily be proved by experiment,

choosing one known wool and one known cotton thread. Silk cuts when bitten and cotton crushes between the teeth. Wool is readily distinguished from cotton by burning. A cotton thread carries the flame burning freely, where a woollen or worsted thread chars, swells, refuses to carry the flame, and emits a smell of burning horn. A woollen thread is distinguishable from a worsted one by noting the direction of the fibres either with the naked eye or through a magnifying glass, observing whether they are parallel or not.

For counting the threads in a woven structure the folding glass known as the piece glass, fitted above with a lens and below with a measured slit in the metal is useful, although a more elaborate and accurate instrument can be had. The threads in one-quarter, half, or whole inch are counted in the lighter worsteds, and in such goods as linings the number of threads forms the only guide to small differences of quality, inappreciable to the eye or touch. Quality of material and size of yarns being the same, that sample which has the more threads is the better. In heavier goods the index is weight rather than number of threads, and values are shaped—other things equal—by the ounces per yard or pounds per piece. Width is a consideration for the study of those who expect economy in cutting cloth for garments. Strength is a factor in making for success in wear, and the Government Departments, for example, use machines for testing the elasticity and tensile strength of the woollens they buy. A sample of determined size is held between jaws and a measured strain is applied. The stretch is noted and the breaking point. The result is more exact than that obtained in the customary way by applying the thumb test. In this rough and ready test the fingers are closed, the knuckles laid in face of each other and the cloth is

held firmly between the clenched forefingers and the extended thumbs. Force is used, keeping the thumbs together and the ease or difficulty experienced in bursting a hole in the fabric by downward straining gives a clue to the suitability of the cloth to resist strains.

The tests with a flame or with the teeth are not ineffective where the yarn tested is all cotton or all wool. They suffice for rough purposes also in cases where a thread of wool is twisted with one of cotton to make twofold yarn. When the cotton is " scribbled " along with the woollen, and is indistinguishable by the eye or touch, these tests fail to tell anything conclusive. A more elaborate means is taken of proving the existence of cotton in this form, but the proof is still easy The sample is boiled in a caustic soda solution made strong enough to dissolve the wool. The cotton remains and by washing, drying, and weighing the residue its proportion to the whole may be established. Cotton is an illicit ingredient in goods described as " all wool," but it is not the case that the presence of cotton is always a disadvantage. A proportion of cotton, sufficient to lend strength, makes an otherwise " tender " woollen of more value from all points of view. Cotton, in the cheap woollens of the day, plays the same part as steel girders in an otherwise unsafe building, bracing and supporting the whole.

An alternate means of detecting cotton lies in dyeing the fabric with one of the colours which will only colour wool. Cotton does not take the same dyes and advantage is taken of the fact in designing goods. The wool is dyed and the cotton in refusing the colour leaves a parti-coloured effect. The so-called union goods, which have a warp entirely of cotton, have an excuse apart from either cheapness or strength. Cotton lies in little room and is eminently pliable, and use of it, along with the

more bulky worsted, produces results not obtainable by using only wool. Manufacturing is utilitarian or nothing, and no one is to be blamed for turning whatever material is to be had to the best use. The grievance, if any, is one of misrepresentation, and woollen manufacturers are too little in contact with the non-technical public to be very guilty in that respect.

The invention of the sewing machine, and the consequent cheapening of the process of converting cloth into clothes, accounts in large measure for the comparative disregard shown to the wearing qualities of wool goods. When cloth itself was dearer, owing to the backward state of mechanical invention, when general wages were lower and garments were made singly by hand, a new suit or a new dress was a rarity of some value. The disappointment was profound if the clothes failed to wear well and look well for a much greater length of time than one expects to wear a modern cheap suit. Fashion changed less suddenly or fashionable decrees were unheeded by a greater proportion of people in our grandfather's days. With the cheapening of manufacture and of making-up, the increase in general spending power, and the growth of Jack's desire to look as well as his master, has arisen a fondness for change of clothing. Clothes are bought more for their looks and low price and less for their solid qualities and real economy. They are not built to outwear their popularity and rather than have one good suit or dress, two different ones at the same cost are preferred by the majority of consumers. The inclination is one that manufacturers have an incentive to encourage.

Clothes not only as good, but better than ever, are made nowadays, but it is rather upon outward looks than on inward worth that ingenuity expends itself. Wearers of the most expensive cloths are the least exacting in the

demand for durability, and buyers of the cheapest know that wearing power is not a thing they have paid for and can expect. The finest fancy worsteds by the most reputed makers fetch fifty per cent more than worsteds, not materially unlike them, but made in larger bulk for a different class of people by less renowned manufacturers. The difference is explained by the display of faultless taste in design and colour, a flawless perfection of weaving and finishing, the excess cost of manufacturing small lots instead of large ones, and the extremely heavy cost of preparing and selecting patterns to please the most fastidious fancy.

Trade necessities rigorously enforce the maintenance of a standard of strength as of other qualities. Cloths disappointing in wear come back to the mill in garment form and claims for damages come with them. The wholesaler rejects goods visibly below standard and a small defect is the source of a disproportionately heavy loss. There is no lack of pains to see that cloths are strong and well-balanced and their colours fast. A minimum requirement is imposed on all goods intended for the market and everything else is relative to price and purpose.

Makers of expensive cloths test the colours that they use by exposing samples to twelve months' sun and rain and judge of their fastness to light accordingly. The resistance of coloured dress goods to street mud is tried by sprinkling a sample with lime and water and brushing off the incrustation when dry. The common standard of the fastness of navy blue for serge is to boil a pattern in a solution of washing soda of the strength of one ounce to one quart. Apart from the wet tests and testing by sunlight is the test for fastness in rubbing. A screw of white paper, or an unstarched white handkerchief, rubbed on the surface of the cloth supplies evidence

promptly of whether the dye is loose. The " crocking " or rubbing off of colour is a weak point, but it is a defect inseparable from use of indigo.

The permanence of finishes is also susceptible of test. The most trying is to lay the sample upon a moist pad and lay upon it a hot iron. The general standard of fastness of finish in such goods as worsted linings is to immerse half a sample of cloth in boiling water until it is thoroughly wetted through and then to allow the sample to dry naturally. The wetted half is compared with that which has not been treated.

Rule-of-thumb tests are supplemented by more exact and scientific observations taken with the assistance of such apparatus as the consultants, chemists, and testing-houses attached to the industry have at elbow. Fine tests are indispensable to detect small differences and are necessitated by causes of dispute, but a great deal of business is done purely on the evidence of the most elementary safeguards.

CHAPTER VIII

TEXTILE TESTING-HOUSES AND TECHNICAL SCHOOLS

THE requirements more especially of international trade have called into being such conditioning-houses as that at Bradford. Conditioning-houses are the assay-offices of textile industry and are most used where the most expensive textile materials are handled. The silk trade is supplied with conditioning-houses in all the Continental centres and the bulk of silk used is "conditioned," or in other words is tested for moisture within them. There are evident reasons why establishments of the same sort should be necessary where wool is handled in bulk. It is not uncommon for spinners to order at one time 1,000 packs (240,000 lb.) of tops worth, perhaps, £30,000. So little as one-half per cent of surplus moisture means on this quantity £150 and the initial purpose of a conditioning-house is to ensure that in paying for wool one is not buying water.

Wool is by nature hygroscopic and varying with its kind and state takes up different proportions of atmospheric moisture. It is against the interest of sellers to send in wool too dry and against that of buyers to pay for material too damp. Accordingly standards of moisture have been arranged and to determine whether wool material is above or below standard it is sent into the conditioning-house, which, in Bradford, is a profit-making municipal institution controlled by a joint committee of the municipality and of traders. Samples are drawn from different parts of the bale and the representative sample thus obtained is reduced to a

condition of absolute dryness. The sample is lowered in a wire cage into the inside of a specially designed gas-oven and dried by an ascending column of hot air. The cage hangs upon one arm of a beam-scale and the gradual loss of weight as the drying proceeds is noted. When the loss has ceased and a condition of bone-dryness exists, the dry weight is recorded and the original weight is compared with that obtained by adding to the dry weight the conventional "regain." On the result of the tests a certificate is issued showing the variation from the standard weight. Regains are allowed as follows—

Wool and waste	..	16 per cent.
Tops combed in oil	..	19 ,, ,,
Tops combed without oil		18¼ ,, ,,
Ordinary noils ..	..	14 ,, ,,
Clean noils ..	..	16 ,, ,,
Worsted yarns ..	..	18¼ ,, ,,
Woollen and worsted cloth		16 ,, ,,

The regain is not identical with the content of water with which it is sometimes confused. One hundred pounds of absolutely dry tops become 119 lb. with regain and the content of moisture is 19 in 119 and not in 100; thus the normal content is 15·96 per cent in the case of oil-combed tops.

Wool materials lose or gain weight according to the temperature and humidity of the surroundings in which they are stored and the conditioning-houses certify what the condition was at the time of delivery, so avoiding dispute caused by excessive moisture present when the goods arrive at a possibly distant destination.

Conditioning-houses are primarily for the conditioning of tops and yarns, but they fulfil other functions. Tops are sampled and examined for their proportion of oil. Yarns are reeled to determine the reality of their marked number or count, and are examined for twist and tested for strength. Piece goods are measured and analysed

and their strength is tested. The testing-houses are less used than they might be in matters affecting only home or local trade. Goods to be sent abroad on journeys long enough to allow of a material change in the original condition as to moisture are the ones most regularly subjected to official test. For their personal satisfaction spinners make their testings on apparatus of their own but to carry conviction to others it is necessary to have independent tests.

Wool material may be damaged at almost any point, and the placing of the blame on the right shoulders is often not an easy matter. The possible causes of mischief begin while the wool is still on the sheep's back and liable to injury by drought and insufficient feeding, or by the use of unsuitable sheep-dip. Delicts in sorting, scouring, combing, drawing, spinning, warp-sizing, weaving, or finishing, directly or indirectly, develop unpleasant consequences later on. Threads with the twist in the wrong direction, the mixture in the same cloth of weft that has been stored for long with weft fresh from the spindle, undue strains or tensions in weaving or finishing, exposure to mildew, and causes more insignificant-seeming in themselves produce effects most difficult to trace and come home unquestionably to the party really responsible for their occurrence. In cases of technical difficulty choice lies between the services of scientific experts and the arbitration of practical men. Points in dispute are referred frequently to the private arbitration of some friend in the trade or are carried to the textile consultant for elucidation by the microscope and instruments of precision.

Testing as well as manufacturing is taught in the technical schools and most of those who rise nowadays in the industry owe something to one or other of these

institutions. The larger colleges are uncommercial mills equipped with every variety of machinery adaptable to the local trade and each takes its colour from the needs of its locality. The fine Bradford Technical College attends especially to all that concerns worsted and a larger share of attention is bestowed on woollens in the still finer Textile Department of the Leeds University. Tweed production is the especial study of the South of Scotland Technical College, Galashiels, and each of the Yorkshire towns has its own premises for education in the needs and methods of the local industry. Instruction is given at nights in the smaller institutes, and by day and night lectures and demonstrations in the larger. The schools illustrate and explain the rationale of mill tasks and aim at the production of better workmen and more instructed managers. Facilities exist for passing on students from the small schools to the larger, and to the universities, and these are being improved. Standard courses of preparatory, elementary, secondary and advanced institutions have been arranged, and in future those students who reach the top of the tree will have enlarged opportunities of engaging in scientific research work. In school the workman is able to learn the detail of the processes anterior and supplementary to those in which he is engaged, to accustom himself to unfamiliar machinery, and to recognize the use and adaptability of different materials.

The courses arranged for students in the textile colleges necessarily vary according to the branch for which the pupil is being trained. The time is divided between the lecture room and the machine rooms, and in addition to strictly technical work the student attends classes in mathematics, chemistry, art, mechanics and languages.

The schools have improved industrial respect for scientific method in testing and manufacturing, but the typical manufacturer refuses to submit to scientific criteria alone. His necessities require him to take raw material as he finds it, and, by such means as he can encompass, turn it to the best account. He demands standards which take heed of the practical difficulties of the situation, and give credit for what he has been able to do and not simply blame for failure to achieve a theoretical perfection. Although not without reason, the demand is one that becomes increasingly difficult to maintain in the face of scientific researches. His work employs several of the sciences—mechanics, chemistry, physics, and electricity, among others—and involves some problems that have been little investigated in the past and as to which the final verdict of scientific study is uncertain. The application of too rigorous or artificial a set of standards in testing is resisted and the tyranny of theory is impatiently borne in the mill.

The textile schools are less expected than at one time to turn out finished manufacturing men and the inevitable failure to do this incurs less reproach. Manufacturing involves much else than book-learning. Doing is of more importance than knowing in the mill, and the understanding of processes is an affair separate from the mastery of men. In school extraneous difficulties are brought to a minimum by the selection and preparation of the material and the presence of skilled advice. In the mill, where material has to be taken as it is found, and where troublesome details have to be met as and when they arise, there is a need for initiative which technical training does not supply as effectively as previous experience. The fact tempers the esteem in which the textile schools are held without seriously detracting from opinions as to their real utility.

CHAPTER IX

THE FINANCE OF THE INDUSTRY

Wool, more than many commodities, is produced, handled, manufactured, and sold by individual rather than by joint-stock enterprise. The grower is an individual trader more often than he is the agent or manager of any pastoral limited company. Public companies and banks receive his wool and advance funds upon it pending its sale in one country or another, but the grower farms his own or his landlord's soil at his own risk. Again, the importer, wool merchant, or topmaker is usually a private trader, making arrangement with those who control publicly-subscribed money, but not one who has shareholders of his own. Manufacturing, too, is carried on far more by private hands than public companies in England. On the Continent and in the United States large sums of shareholders' money are invested in woollen and worsted industry. Here the rule is that the funds are the manufacturer's own or those of his family or private partners. The fact that so many manufacturing firms add " limited " to their name implies no more than a wider adoption of private limited liability.

At this point the wool industry shows in some contrast against cotton, and it may be asked why the wool industries have found less need of outside assistance. Inquiry will show that the joint-stock principle in cotton is most prevalent in the spinning branch. In the weaving trade, in which one may start with relatively small means, cotton manufacturing is also principally

in private control. Cotton is a larger and more standardized industry. The raw material is not more expensive, but the output and orders are larger and conditions in cotton spinning are more favourable to a large or moderately sized than to a small concern. Then a cotton spinning mill is equipped to take in raw cotton and perform all processes incidental to the production of yarn. There is no division—as in worsted—between the combing and the spinning branches. The smaller worsted trade, with its more irregular requirements and its division into two parts, gave an opening to men of smaller capital than that required in the cotton spinning trade. There is not much public money in the English wool industries because there has been little need of it.

Starting in a small way as comber or spinner a man was—and in spinning still is—able to keep his plant in a state of efficiency similar to that of his larger neighbours. As a woollen manufacturer a relatively few thousand pounds would buy the complete set of machinery necessary to make a living and allow the manufacturer to find a groove of his own. The public companies in the wool industry have been formed more often to take over established enterprises than to promote new ones, and it is for the former purpose that public money can the more readily be found. The materials bought and manufactured are costly, and with the sums at their disposal beginners, in Yorkshire at any rate, could not have succeeded so without substantial aid from the banks. Bank overdrafts on the security of purchases of wool, mill premises, and machinery, have been more liberal than in some parts of the country and have enabled the industry to dispense with other help.

The working capital required in manufacturing is conditioned by the length of time taken in passing goods through their process and by the terms of credit in

vogue. Wool sells at auction for cash, commonly with an allowance of one or two lb. per cwt. for draft. Tops are sold for cash in seven days, subject to four months' discount (i.e. fourpence per £ = one penny per £ per month). Yarn is paid for about a month after delivery, the terms varying with local usage up to two months.

Cloth terms have been more irregular, according to the class of cloth concerned and the district of production, and have provided for monthly settlements after a lapse of one, two or three months, or sometimes for season's terms. Under the last-named system the customer paid at the end of the season for deliveries made within the season, so making two payments a year and obtaining six or nine months' credit, while the manufacturer often only drew payment for his cloth a full year after paying for his wool. Those principally concerned in the long credit system drew up an agreement having force from 1st August, 1916, whereby all shorter terms are countenanced and the following maximum terms are laid down—

4%	discount	if	paid	for	on or before	the	month	following despatch.
3½%	"	"	"	"	second month	"	"	
3%	"	"	"	"	third month	"	"	
2½%	"	"	"	"	fourth month	"	"	

The agreement is signed upon behalf of the Central Committee on Trade Terms, the Wholesale Clothing Manufacturers' Federation of Great Britain and Ireland, and the Federation of Woollen Merchants and Shippers of Great Britain and Ireland. Rigid enforcement of the terms is explicitly declared to be in the interests both of buyers and of sellers.

Overmeasure, to compensate for the contraction of cloth upon wetting has been customary in the woollen trade for at least 500 years. A statute of 1415 prescribed that the woollens known as "Dozens" must contain not twelve yards but fourteen, and a few years

later London merchants were seeking to encroach upon the custom already established of selling cloth " by the yard and the full inch "—in other words 37 in. to the yard. By 1514 the clothmaker of the period was obliged to " deducte of his price " to the buyer for any greater shrinkage than one yard per piece when the cloth " shall be full wett." The citations vouch for the antiquity of the trade customs whereby most woollens and some worsted fabrics have been sold in yards of 37 in. measure with an allowance of one yard per piece, one yard in forty yards, or one-quarter yard in ten yards. These conventional allowances were not universally applicable even in ancient times and in modern days they have not applied to women's dress goods for example. Under the same agreement that has abolished the long terms of credit a majority of the more important manufacturers have dispensed with the customary allowances of one-thirty-seventh and one-fortieth. These have been replaced by a new overmeasure in which 38 in. is reckoned as the yard, except in the case of goods hitherto bought on a basis of 36 in.

The worsted trade in its later development has opened opportunities to the " small man " who can get a portion of his machinery on credit. The room or mill is rented and the rent in some cases includes engine-power. With five or ten thousand worsted spindles or thirty or forty looms, the beginner has a fair start. There are " manufacturers " and " spinners " without looms and without spindles who buy yarns and send them to a commission weaver, or buy tops and put them out to a commission spinner. The arrangement has both good points and bad. The owner of the material is freed from the shackles of machinery which clamours to be fed with work, be times good or bad.

On the other hand, the mechanical processes are either not so well done or so cheaply done as by the fully-equipped manufacturers. The system is of convenience to those who have not capital enough (*a*) to buy and treat material, and (*b*) those who have money for material but not for plant. The existence of the commission worker is of advantage, too, to the spinner or manufacturer who does not wish to extend his mill. Keeping his own machinery in full work at all times and sending his surplus to be treated outside, he avoids those dead expenses which go so far to neutralize the profits from the mill.

The absence of inflation of capital, the ability to raise money on advantageous terms, the cheapness of coal, the cheapness of building, the purchase of machinery at its first cost instead of at a price increased by heavy packing, freight, and customs charges, the abundant supplies of soft water, the assistance of an atmosphere friendly to spinning and weaving, stand the British woollen and worsted industry in excellent stead. These advantages, if small singly, are cumulative and not unworthy of mention in the same breath as the apt and docile labour, the thoroughly sensible and conscientious workmanship which the British manufacturer commands. By the side of Continental wages, British woollen wages are high and are not as low in relation to American wages as is sometimes represented. What is more important than price is that the service rendered is of the best kind and unsurpassed by that of workmen anywhere.

CHAPTER X

TRADE COMBINATIONS

COMBINATION, whether among masters or men, in the wool manufacturing industries has, until late years, been weak, and presumably because conditions have not been highly favourable to either. Trade unionism does not find its most congenial soil among young women, who, with children, form a large part of the operative class. Nor does the topographical distribution of the parts of the industry favour the combination of workpeople. The woollen trade is carried on largely by scattered groups of workers of different grades, working at separate tasks, and living in isolation from the similar groups employed not many miles away. Where the industry is most centred, and where men are employed in relatively large masses, the unions are strongest in point of number. The overlookers in the worsted spinning and weaving mills and the power-loom tuners of the woollen trade are the non-commissioned officers of the industry and have associations of their own, necessarily limited in membership, which are still highly effective in regulating conditions of service. Cloth pressers and warp dressers belong to select trades which also have societies that are strong enough for their work. The wool sorters are a relatively strong organized body, and the combers have attained a considerable strength. The willeyers and fettlers employed in the carding departments form a fairly strong union along with the weavers employed in Huddersfield. The dyers' unions have an all but complete grasp on the trade and, under the leadership

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of the dyers' unions, a federation of trade unions comprehensive of nearly all sections of woollen worsted trade unionism has been established and the collective agreements made with the associations of employers have at least had the effect of stabilizing wage-rates over considerable periods of time.

The increasing pressure of the trade unions, the shortage of labour and the extraordinary circumstances of the state of war, have forced a closer co-operation between manufacturers and employees of all degrees. In substantially all districts and all sections of the trade, local associations have been formed to determine questions of wages and working conditions, and to discuss trade policy. Federations linking these sectional associations unite the district bodies, and for the larger common purposes of the industry all together are combined in a national organization. Importers and handlers of raw material, spinners of yarn, manufacturers of cloth, merchants, and shippers of goods are united in the Wool Textile Delegation of the United Kingdom, which has been established as a medium of communication between the industry and the Government.

The Chambers of Commerce in the manufacturing districts have been the chief associations of employers, and they are loosely formed for many other objects than collective dealing with the grievances of the employed. The Chambers maintain Conciliation Boards registered at the Board of Trade for the purpose of intermediation in acute cases of dispute. They provide a platform for the airing of views on all subjects allied with manufacture, but are not comparable with bodies formed to compensate members who may be faced with strikes, nor are their judgments binding upon the individual members.

Industrial conditions have hitherto been unfavourable to associations of employers having for their object the maintenance of prices. Apart from the "combines" in which there is a fusion of capital, no organizations with this end in view have had any prolonged existence. The failure of collective efforts to limit price-cutting formed a cogent reason for the amalgamation of firms into the textile combines. Dyeing and combing call indeed for skill, economy, and good management but they are only two processes out of several, and combing, at least, has less to do with determining the individuality of goods than have spinning and manufacturing. The individual choice of raw materials, and the individual ways of going about the methods of manufacture result in giving to articles, nominally alike, a distinguishable character of their own, differentiating the products of one manufacturer from the productions of another. These fine differences can only seem inconsiderable to those who do not know the by-ways of trade, and it is because of one or another of these that one make of article is preferred or insisted upon. The maintenance of a distinct individuality in the goods turned out leads in turn to an individualism of demand and to inequalities in price which do not contribute to the harmonious working of an arrangement to preserve a certain minimum. Perhaps in no industry have these distinctions been utterly abolished and in the wool industries, with their infinite varieties of production, individuality has an exceptional play, which, if it obstructs combination, at the same time removes some of the necessity for joint action in order to maintain a remunerative level of price.

There is a private interchange of opinion on market-day, or such other occasions as throw acquaintances

together. Textile societies exist principally in connection with the technical schools and their main purpose is the reading and discussion of papers. The Textile Institute of Manchester is the nearest approach to such Institutes as exist in connection with the metal trades for the dissemination of technical information among manufacturers, as distinct from learners or students. Combination—in short—is not a spontaneous growth in any department, and the fact is one that it is more customary to accept than to deplore.

Some real differences in earnings can exist where competition is indirect. It does not seriously matter to employers whether they pay more or less wages than manufacturers who are not working for the same market and making similar goods. Nor does it matter whether wages are apparently high if the real cost is low. The true measure is efficiency, and apart from advantage in this direction a manufacturer gains some reflected glory from his address. To be a Huddersfield worsted manufacturer, a Galashiels or Hawick tweed manufacturer, or to carry on business in the West of England, is enough in itself to raise the individual out of the ruck of some sorts of competition and to justify the asking of a certain price. Situation in the established homes of the industry does not in these later times guarantee a sufficiency of skilled help, but at least it brings some choice of apt workers skilled in the particular kinds of work peculiar to the neighbourhood.

Once it was water that a manufacturer sought in looking for a site to build a mill, and from the earliest times the mills have clustered round the streams that fed them originally with power and constantly with water for scouring and dyeing. Now it is for sufficient relays of labour that he must look, and already the

worsted spinning industry has been tempted towards new colliery districts where men are well employed and local work for women is absent. The movement may go farther in future, although this probability is contingent upon factors that cannot be foreseen.

CHAPTER XI

PRODUCTS AND BY-PRODUCTS

By the name raw wool is to be understood wool direct from the back of the sheep, in which condition the greater bulk of the supply is "greasy." Most English wool comes to market "washed" by the immersion of the sheep in cold water some time before clipping, a process which has the effect of removing, perhaps, half of the natural impurity. In a few English districts the treatment is more thorough, and "tub-washed" wool is still cleaner. In contradistinction to greasy "scoured" is the principal variety, and in this state the fleeces are opened and broken and a fairly complete riddance of grease and dust is made by the use of warm water and alkali in a wool-scouring machine. Unscoured wools in the fleece are "classed" by putting together those of similar quality, or are "cased" by the wool merchant. The act of casing is simply a further process of selection, not involving the breaking-up of the fleece. "Sorted" wool consists of fleeces that have at least been unrolled and scanned and have had some less desirable portions removed. The thoroughness of sorting varies with the needs of the case, and often no more is required than that the fleece shall be broken into two portions, one-half forming one sort or quality and the other half another. "Matchings" are made when wool is duly sorted and the corresponding sorts of fleeces of one quality are bulked together.

Wool-combing produces, on the one hand, "tops," and on the other hand "noils," or short fibre more or less laden with vegetable impurities. The tops are either

" oil-combed " or " dry-combed " accordingly as oil is used or not. The noils vary in length of fibre in correspondence with that of the original wool and with the type of machine used in combing. Scoured wool and noils are sometimes " carbonized " or baked in acid with the purpose of reducing their vegetable impurities to a friable condition, thus eliminating them.

More or less all the processes of manufacture create some by-product, known generically as " waste," although in point of fact the material is never wasted. In spinning tops into yarn there is some involuntary production of " laps " which are broken lengths of sliver, a few feet in length. Fibre accumulates as " roller waste " on the spinning rollers or floats as " fly waste " about the room. " Roving waste " is made on the roving frame, and a certain amount of thread or bobbin waste is made in spinning and twisting yarn. These by-products of the spinning room are classified as hard or soft accordingly as they are or are not spun and twisted. The " flocks " used as stuffing and bedding are rag-flocks, made in shredding woven rags to fibre again or are otherwise worked from woollen fabrics in the course of finishing. Flocks are generated in scouring and milling cloth, and also in raising the surface and in shearing or cutting away the surface.

Yarn is " single " (one strand) or twofold or more, and when used for warp is commonly harder-twisted than for weft. Worsted yarn is spoken of frequently as " white " when undyed and as " coloured " when spun from dyed tops. Worsted yarns take names from the quality of material out of which they are made—as " Botany," " crossbred," " English "; and also from the purposes to which they are to be put as " hosiery," " coating," " gabardine "; and sometimes from the

method of production as " cap-spun," " flyer-spun " or " mule-spun " in the case of combed wool spun upon the worsted mule. The " lustre " yarns are those made from strong, hairy English wools, and the " demi-lustres " are those approximating to them. When these bright yarns have been passed through gas-flames to singe off projecting ends of fibre they are known as " genapped."

Woollen yarns are known rather by the purpose to which they are to be put, and are sold frequently with a guarantee as to the absence or proportion of cotton. Like worsted yarns they are sold " scoured "—which means that the yarn has been washed after spinning—or " in oil," when the oil used as a lubricant in carding remains. The initials O.B. (open-band) or X.B. (cross band) following the name of a woollen yarn denote the direction of the twisting, right-hand or left-hand.

In the British official classifications used for recording imports and exports the unit is the square yard and not, as formerly, the running yard.

In the official categories the divisions are—

Woollen Tissues.	All wool or mixed.	Weighing per square yard— 16 oz. and over ; 12 oz. and under 16 oz. ; 8 oz. and under 12 oz. ; under 8 oz.
Worsted Tissues.	All wool or mixed.	Linings, lastings, etc. Other tissues. Weighing per square yard— 12 oz. and over ; under 12 oz.

Trousering and vesting cloth is customarily single-width (or 3/4 = 27 in.). Coatings and a majority of costume cloths are double-width (or 6/4 = 54 in.). The widths are frequently exceeded in cloths of superior

quality and thus single-width becomes in many instances 27-29 in. and double-width 56-58 in., or even more. Widths between 48-52 in. are met with most frequently in heavy cloths of cheaper varieties. Lighter makes of cloth for dress-goods are commonly spoken of as double-width when finished 40-44 in. wide, but economy in cutting-out garments favours the broader measure.

Cloth "fents" are remnants of short length, commonly bought and sold by the pound. "Ends" are lengths of cloth longer than fents but shorter than whole "pieces." A piece is not a fixed length but there are customary lengths such as 50-60 or 60-70 yds., and in part these are determined by the weight per yard and convenience in handling. A "string" is a deduction from length; a tag of string tied to the list of the piece signifies the presence of a hole, stain or defect in compensation for which usually one quarter yard is allowed. Samples of cloth are ordinarily called patterns rather than samples.

By "fancy" yarn is meant usually a thread with irregularities such as loops or knots produced purposely in twisting. A "mixture" yarn is one of two or more colours, and a mixture effect in cloth is one in which colours are employed not to form any symmetrical pattern but simply to present a broken appearance. A "plain" cloth is one made in any of the simple weaves and in the ordinary colours, black or blue. Fancy cloths are the outcome either of variations in weaving producing patterns by regular changes in the structure, or of the orderly introduction of coloured threads.

The plain woollens within the ordinary scope of the term are the self-coloured smooth-faced cloths like the melton, beaver, box and livery cloth. The fancy woollens are the tweeds. The plain worsteds are the

GREASE RECOVERY FROM WOOL SUDS

ordinary twills and serges and the fancy worsteds are the striped, checked or patterned suitings and trouserings. With dress-goods and linings these articles comprise the greater part of the woven products of the wool industries, but mention must be made also of blankets and flannels. The " Witney," or raised blanket, woven from relatively thick yarn and with a pile teased upon its surface, and the " cloth " or Bury blanket are the two main varieties. Flannel unqualified by any other name is an all-wool cloth made with soft springy wools and subjected to comparatively little finishing. Flannels qualified as " Austrian," " Ceylon," " Tennis," " Shirting," and so forth are not necessarily all wool, and flannelette is composed entirely of cotton. The plushes made by weaving mohair over wires and by cutting the loops thus formed are members of a large family of pile-fabrics manufactured in all degrees of diversity. By being printed in colours, cut and embossed, some of these goods are made in imitation of furs and skins, and the natural curl of astrakhan is duplicated by first twisting and boiling the yarn used in weaving so as to give it a permanent set.

The pile fabrics touch hands with the manufacture of carpets. The Brussels carpet is a loop structure woven over wires with the warp loops left uncut. The Wilton carpet is virtually the Brussels carpet with its loops cut. The cheaper tapestry carpet imitates Brussels with the difference that its pattern is formed by printing it in an elongated form upon the warp before weaving. The tapestry velvet carpet is simply tapestry with its loops cut. Worsted warps are used mainly for the four types of carpet already named, and woollen yarn mainly for Axminster and chenille Axminster carpets and rugs. Tufts of wool yarn are formed and cut in the loom in making the best Axminster.

The chenille Axminster, which allows for the greatest freedom of pattern and the avoidance of seams in the goods is, like the light chenilles, twice woven. First, a fabric with an elementary cotton warp and woollen weft is woven in predetermined colourings, and then this fabric is slit lengthwise so that a fringe of cut wool yarn is held by the cotton threads of the warp. This cut fringe, spoken of as "the caterpillar," is woven across another warp to form the finished carpet.

In England felt-making has not been a highly important department of the woollen industry, and has flourished more in countries with cheap labour and abundant supplies of water. In the true felt there is no woven structure at all. The noils or wool used are first scoured and blended, and worked on a carding machine. Successive layers of the carded wool are laid film upon film above each other until the desired thickness is attained when the whole is pressed under heat by vibratory rollers. The whole is amalgamated with soap, water, heat and pressure.

Yarns for the manufacture of small wares have been made in great quantity in England and been exported to Germany where they have been woven into braids for edging and ornamenting garments and upholsterings, for making button covers and laces and for innumerable small purposes. In the completed state much of this yarn has returned to England to be consumed in Great Britain and the Colonies.

The production of wool goods for other purposes than those of personal wear or domestic furnishing is not inconsiderable. Wool fabrics are used in mechanical industry by paper-makers, for example, calico printers, and letterpress and lithographic printers. In expressing oil from seeds, wool and hair cloths are largely used as filters separating the crushed seed from the oil. Strong

heavy wool fabrics of narrow width are used as driving belts for machinery. The healds used in the loom to lift the warp threads in succession are generally made of hard-twisted worsted yarn. Wool and hair make good but expensive hoods for motor-cars, and wool cloths have come into use in warfare in substitution for silk as containers of cordite for the charging of big guns. One employment of wool, which is decidedly more important commercially than might be imagined, is its use in making imitation hair, chiefly for dolls. English wools of sufficient length and lustre are preferred for the purpose, and after being combed the material is dyed and curled by continuous machinery.

The fibrous products and by-products of wool are systematically utilized, and the non-fibrous are not disregarded. The sweat or suint of the sheep transfers to the fleece a proportion of the potash salts present in the soil of the pastures and the valuable mineral is recoverable by steeping the wool in cold water when the carbonate of potash is dissolved. The process is made economically advantageous when a certain degree of concentration can be reached, and it has been most practised in the countries in which greasy South American merino wools have been most used.

In England the vegetable matter lodged in the teeth of the carding engines is carefully bagged and is sold for manuring hop-gardens and vineyards. The dust extracted in willeying such wools as the East Indian varieties is also taken as manure. The chief non-fibrous by-product in English practice is, however, wool grease, recovered from the waters of the scouring bowl. The sud is passed into a tank and treated with common vitriol or with nitre cake, causing the fats to separate out and rise in the form of scum. The clear water is passed away through a chain of filters, and the grease

scraped from the floor of the tank is enveloped in canvas squares. The grease goes to the hydraulic press, is heated in a steam jacket, and put under pressure, causing the oily constituent to exude. The fluid is passed into barrels and is either sold to distillers of grease or thinned with some lighter oil and returned to the mill for use again in oiling wool for carding. When refined, the wool fat, or lanoline, becomes a basis for ointment and an article of toilet. The hard cake resting behind in the press cloth is used for fuel and for manuring hop gardens.

CHAPTER XII

THE PERSONNEL OF THE INDUSTRY

THE general survey would be incomplete without some brief consideration of the multitude of widely different persons engaged in carrying on the great wool industry. The account may begin with the shepherd who, in England at least, is commonly a skilled, intelligent, and faithful man, whose remuneration in cash and in kind is something like a pound a week for knowing all that is to be known, and doing all that is to be done, in the care of his charges. He knows his sheep by their faces, and can identify the parents of his lambs. He recognizes and treats their ailments, and in lambing time works both day and night. A bit of a surgeon, more than a bit of a butcher, a useful man with the shears or on the turnips, an expert in the use of dogs, a good haggler, a good judge, and very often a natural philosopher, the modern shepherd in these islands gets less recognition than he deserves.

In picturesque qualities the homely shepherd may be outclassed by the station hand of Australia, the half-castes of South America, and the nomad shepherds of the East. He is admittedly less expert with the shears than the professional shearers in Australia who make their two pounds a day by exceeding ability in the use of the clipping machines which have replaced the old tong-like shears. Wool raising is not a separate industry affording play for subdivision and specialization in this country. But extending the view to the whole wool-producing world, a motley legion of people are found in it. Besides the station hands and riders

and lonely hut shepherds, who see no other man for a month at a stretch, there are the port workers, the pressers or " dumpers " of wool, the auctioneers and brokers, and clerks. Back in the country are the storekeepers whose whole livelihood pivots on the production of wool and the sale of wool packs, twine, sheep-dip, medicine, and station rations.

On the East of the Atlantic, in the places where preparation for manufacture begins, are the wool warehousemen to be seen leaning from crane doors, clad in the uniform of their calling, the long blue and white smock, or " checker-brat." Inside the warehouses, working at screen-topped tables facing cool north lights, are the woolsorters examining and breaking up the fleece. If they work with the scheduled dangerous wools and hairs they work under set precautions with a downward draught continually carrying off the dust that their manipulation of the wool dislodges. Anthrax, or woolsorter's disease, contracted from Eastern wools and hair, is their principal and, perhaps, their only considerable foe. Their work is healthful, and if the stationary position leaves the sorter exposed to cold in winter he has at least the advantage of a cool atmosphere in summer.

The Education Act of 1918 put an end to the system of half-time employment whereby children of twelve, upon passing a severe examination, were enabled to work in the mill alternately in the mornings and afternoons, for the rest of the day attending school. Young children are of service, especially in worsted spinning. They take off and put on spinning bobbins, remove the accumulating fly-waste from the spinning rollers, and learn the delicate art of piecing together ends of worsted yarn. From the standpoint of industrial perfection, the earlier the child begins to practise the suppleness and

deftness necessary in making a neat job of piecing broken yarn the better. A girl makes a better spinner for life by beginning at the age of eight than by beginning at nine, and better by beginning at twelve than at fourteen. The change is one out of several affecting the quality of the worsted yarn produced in these times as compared with that of years ago.

Inside the mill they are comfortably warm in an atmosphere that even in winter is maintained at or about seventy. In the dark of a cold, wet morning, it is possible to feel that the advantage of an early initiation into mill life may be exaggerated. All but a few of the boys perforce leave the spinning department, the girls stay on and graduate as minders of spinning frames, earning wages corresponding with the number of frames tended. Automatic doffers for spinning frames and the protests of school authorities foreshadow the eventual disappearance of the half-timer.

For men, worsted spinning provides work chiefly as overlookers, who have the oversight of the work done and are responsible for the changing of wheels and the setting of machines. All the mechanism of the drawing department is adjusted to a calculated end, and different adjustments of speeds and distances are made for different classes of material and counts of yarn. The changes are made by substituting wheels, and the complete overlooker is a man of figures, using logarithms and the slide rule ; he is more or less of a mechanic and a tactful disciplinarian. The overlooker is paler and sparer than the worker out of doors, but of the right stamina for the mill. His occupation is interesting to men of the right bent, and in some countries an English overlooker is better paid and more esteemed than at home. Specimen Yorkshire overlookers are to be found in nearly all the worsted spinning countries. They work

in France, Germany, Holland, Belgium, Austria, Russia, North America—indeed, wherever there are British worsted spinning machines.

Of quite a similar type is the weaving overlooker, or power-loom tuner, as the woollen trade prefers to call him. His forte is a complete understanding of the complex mechanism of looms, an ability to understand and remedy their disorders and, on being given a ground-plan on squared paper, an ability to mount a loom to weave any given design. Overlookers, if they are studious, fortunate, and able, grow up into managers who assume full mechanical control and complete charge of the workpeople. But to make a complete weaving manager one has usually to be also a designer. Designing calls for a double aptitude for the designer is the architect of cloths. His designs may be replicas of those of other men and demand no more than a technical knowledge of cloth structures, in which case the designer is more a builder than an architect. It is the business of designers of the higher class to add to mere mechanical ingenuity, taste, invention, and skill in detecting and forestalling the trend of public fancy The designer in the fancy trades may make or break the mill, and large salaries are paid to the best designers. Those who are gifted salesmen and managers as well as designers command salaries commensurate with their abilities, upon a higher scale than that of the man of purely technical qualifications.

Weaving employs many women and few men. Trial patterns on hand looms, the most expensive worsteds and woollens are woven by men, but two out of three of all the persons in and about the weaving sheds are women. Female labour is cheaper than male although less resourceful, and cheapness and its concomitant abundance, explain the presence of women in the weaving

shed. The racket of a hundred looms dismays a visitor. Shouting barely enables him to hear his own voice, but the weaver's ear is attuned to the rattle and uproar and heeds it as little as the city dweller the sound of the traffic. The sheds are most often bare and white-washed, well lit because of the need of the work and warmed to 60 or 65 degrees F. There is no " steaming " of the atmosphere as in certain branches of the cotton trade, and the operative minds only one or two looms. The monotony of the task of tending the machine is broken by the minor incidents and accidents, the necessity for replenishing weft, watching the pattern to see that all is well, and the restarting when anything is amiss and the loom " bangs off." The work is more popular among women than domestic service, and in some quarters is more popular than work with the sewing machine. The work is not beyond the strength of women, and not incompatible with good health and good looks.

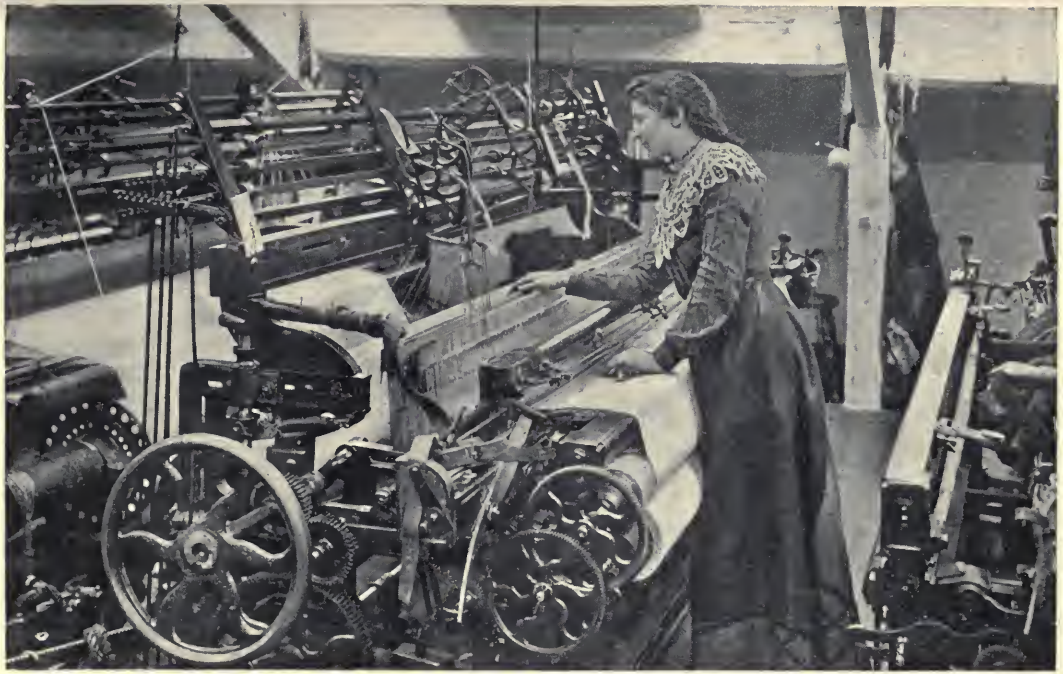
Taking the woollen, worsted, and shoddy industries as a whole, the proportion of men employed to women employed is roughly as two is to three. The women do the light and routine work, the tasks that call rather for patience and deftness than initiative. The men do the rough work and that which puts most tax on the intelligence. Men officer the industry and women leave it to be married or remain in the ranks. Seldom, indeed, do they rise to positions of control.

The male weavers retain marks of their heritage from those who worked at the hand looms, and although unable now to play cricket in mid-week and steal the lost hours from the night, they are a steady and an independent breed. Their work is pleasanter than that of the willeyers and fettlers who man the card-rooms, but less remunerative than that of the spinner of the

woollen trade, or of the warp dressers or the twisters-in who thread and fasten the warps into the looms. A less skilled but moderately well paid class of men find work in the dyehouse. The foreman dyer accepts responsibility for the colours and the materials to use, and the dyehouse labourer fetches and carries, or with one hand lightly steers the passing cloth in or out of the machine. The dyehouse atmosphere is one of steam and fumes, and its floor is slopped with coloured water. Its machines, filled with boiling liquids, make it on the whole an uninviting place. It is possible to be more at ease in the warehouse examining the cloths that are the outcome of so many operations and trying processes.

In reaching the manufactured stage wool employs many, and in passing into consumption it employs many more. The woollen merchant, with his warehousemen, clerks, and staff of travellers, the tailor and dressmaker with their workpeople and assistants, and the factory clothiers with their thousands of hands, and the machine knitters are parties to the industry rather than camp-followers. The list might be indefinitely extended by inclusion of the allied trades—the makers of looms and spindles, the tanners of the leather that is extensively consumed in combing and spinning, the oil, soap, and chemical people, the makers of aniline dye wares, the bag-makers, paper-makers, case-makers, and printers directly dependent on the wool production who constitute an army in themselves. Let it suffice to deal shortly with the bare beginnings of the great distributive system, the merchants who set the goods rolling down the long incline on their way to the ultimate consumer.

The customers of the mills are of two broad classes. The home-trade merchant, serving, and in some measure financing, the tailor or draper, is distinguished from the



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GIRL WEAVING AT LOOM

shipper or shipping merchant in buying to stock. He orders in advance of the season, buying in large quantities and selling in small. The shipper, supplying wholesale merchants or clothiers abroad, buys to cover orders as they are received, sends out a ceaseless stream of patterns and dispatches travellers to the markets he especially cultivates. The shipper's position is closer to that of an agent, and it is in seeking and offering the goods that distant parties are likely to buy, examining them before shipment, seeing to their proper packing and the routine of forwarding and finance that he is useful and, indeed, indispensable, in all but exceptional circumstances. The textile manufacturer is remoter from retailer and from consumer than manufacturers in some other trades, for reasons not difficult to understand. The retailer wants small quantities and large variety; the manufacturer wants orders for large quantities of preferably a small variety. The wholesale house bridges the gulf, giving the manufacturer orders of the size he needs for economical working, and giving the retailer the choice of a wide selection. The manufacturer is comparatively little known outside his own locality and direct customers. Woollen mills employing thousands of hands are less famed publicly than factories producing goods to not one-tenth of the value. Only the makers of particular specialities see fit to advertise, and for this there is a natural reason. The goods they make—cloth or yarn—are not turned out by them in the form ready for immediate consumption. The yarn must be turned into cloth and garments before arriving at the condition in which wool is principally wanted by the ultimate consumer.

The garment-maker advertises widely and boldly such articles as raincoats, and the hosiery manufacturers make increasing use of trade-marks. The one

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FINAL EXAMINATION

sells a coat that is made in one season of one fabric and in the next of another. The hosiery manufacturer sells a garment that is little susceptible to fashionable influences. The dyer or finisher, who impresses upon cloth not his own property, the name and trade-mark of some special finish, draws attention to an effect which can be produced on any similar goods. Their position differs from that of manufacturers who have to produce different goods for different seasons, and to sell them in bulk to customers who object in most cases to deal in goods branded or advertised in any name but their own. The advertising of woollen and worsted fabrics may grow further in England, and is growing in the United States, but essentially it is a method applicable more to profitable specialities of a relatively fixed character than to the drugs of the market or to fabrics which have only an evanescent demand. Meantime, outside their own circles, the identity of manufacturers is little known.

CHAPTER XIII

WOOL IN WARFARE

IMPORTANT as wool is in peace, it gains an additional importance in war as clothing for the armies and for the purposes of the artillerist. The consumption of wool is immensely increased in modern warfare, because the clothes of a soldier campaigning in temperate climates contain more wool than those of the average civilian and are much more quickly worn out. Both in fact and in name, wool is a war material, and it is subjected by the several governments to the regulations governing such materials in transit. The ordinary effect of war upon the wool markets, as instanced in the South African and Russo-Japanese campaigns, is to force up the price especially of the kinds of cross-bred wool best suited for making uniforms and of the coarse wools employed for Army blankets.

Wars of moderate dimensions set up no specially great demand for merino wools, which are ordinarily taken for little else than officers' uniforms; but the world war compelled the employment of wools of all types in order to make the fullest use of the existing manufacturing machinery, and keep pace with the appalling rate of destruction. Military cloths have been made traditionally to certain standard patterns, evolved in course of long experience, as being the best for the work. In the European War, these standards were modified to suit the pressure of the times, with a view both to the utilization of the available forms of raw material and the quickening of production.

A mobilization of the Imperial resources of raw

material, and of the machinery for converting the wool into yarn for knitting into socks, gloves, and underwear, and for weaving into cloths for tunics, breeches, overcoats, shirtings, flannels, blankets, and cartridge linings, began with the purchase in 1916 of the entire British and Irish wool clip. British-grown wools, hitherto little used for military clothing, were bought at a valuation based upon the prices ruling immediately before the outbreak of war. An organization to administer the supply of British wool to contractors, and its sale to manufacturers engaged in private business, was set up under authority from the Army Council. Only duly authorized merchants were allowed to receive and deal with British wool, all purchases of which were made by newly-appointed officers. These merchants in the several districts of production and centres of consumption were appointed to sort and store the clip, and to pass the wool upon instruction to specified Government topmakers, under whose orders the wool was combed.

The purchase of the British clip was followed by arrangement with the Australian and New Zealand Governments for the acquisition of the Colonial supplies, and by negotiation for the South African clip also.

Placed thus in effective possession of the supplies of wool, the Government controlled both its prices and its destination. Schedules of prices for tops of different qualities were adopted, and, having dealt with the cost of the prime material, prices were fixed also for the execution of manufacturing processes upon terms made in relation to the ascertained cost of working. The system limited the cost of goods required under official contract for the British Government and its Allies, while leaving manufacturers to make their own bargains in dealing with customers in civil trade.

A summary statement of the means employed to bring a complex trade and industry under a central control, tends to give a false idea of the ease with which the operation was effected. War, in which the principal manufacturing nations are the belligerents, in itself brings about a great dislocation of established trade practices, and the changes incidental to the control of prices and production necessarily bring more. The advice of business men was sought and, in some measure, followed in reorganizing the wool business. Men taken from the business were appointed to Government posts; but more than a year after the inception of the scheme, and after many changes, it was still found susceptible of improvement at one point and another.

The full consequences of the war upon the development of the wool trade rest to be revealed in later years, but some notice may be paid to the immediate consequences. The war in cutting off commerce with the Central Empires released for consumption elsewhere the large quantity of Colonial wool imported into Germany in a raw state, and the occupation of Belgium and the manufacturing districts of Northern France released more, and chiefly wool of merino quality. At the same time, there ceased the large German and Austrian consumption of cross-bred British wool and mohair obtained in the form of tops and yarn from Yorkshire. The important trade with enemy countries in woollen and worsted fabrics, largely of high quality, also disappeared. In place of these was substituted the increasing demand for clothing for the new armies and for fabrics for civil wear, replacing those which would normally have been manufactured in France, Belgium, and Germany. The sum total was a radical change in trade requirements, aggravated by

difficulties in obtaining necessary materials such as dyestuffs, and complicated by the impossibility of collecting large debts due from customers in hostile countries, and by a strong rise of prices. There was no standstill such as appeared inevitable in advance, because new demands more than compensated for the loss of old markets.

The war brought into English use types of wool which British manufacturers had hitherto shunned, and it reversed the tendency of manufacturers to produce an ever-growing diversity of goods. Demand being predominantly for standard Army cloths, the machinery of the industry was devoted to the production of a few articles in the utmost possible quantity. The possibility of producing extensive ranges of fancy goods was limited by the difficulties of dyeing, the shortage of labour, and the insatiable demand for cloths that could be had quickly. The effect has been to level manufacturing practice all round, and the process has been assisted by the measures taken in securing control.

Practice in sorting, blending, and manufacturing wools and woollens has been assimilated to a common level. Merchants and manufacturers have learnt more than ever of each others' ways of arriving at a given result, and there is at least the probability that an exchange of experience, which has by no means been entirely voluntary, will leave permanent traces upon the later development of the wool business. Permanent effects must be expected also from the great rise in wages, notably in those of young persons, which rise is not usually accompanied by any corresponding increase in output. The higher costs of working must necessarily cause greater attention to the use of labour-saving machines. While imposing a great strain upon machinery, as upon persons, the war presented

signally few opportunities of making good a wear and tear that is ordinarily repaired piecemeal. The war has been followed by a great demand for most kinds of textile machinery. The production of fabrics of novel design, suspended during the war years and during the post-war boom in trade, has been revived again under the pressure of competition. Once again goods are ordered and made specifically for given seasons, and a condition of uniformity has given way to diversity. The new conditions of the world seem to ensure that this change shall continue.

GLOSSARY

Alpaca	Hair of the Peruvian llama (Auchenia paco).
Back washing	The second scouring process given to tops.
Bale	Australasian bales of wool weigh about 3 cwts.; Argentine bales about 930 lbs.
Botany	Synonym for Merino wool; fine wool.
Burling	Removing surface imperfections from cloth.
Carding	The teasing-out of fibre by the aid of fine steel wire points set in rubber or leather foundations and mounted on cylinders.
Cashmere	Hair of the Kashmir goat; also a dress material made from the Botany wool; applied by tailors to worsted trouserings, etc.
Cheviot	Wool from Cheviot sheep. In Scotland a name applied to the coarser wools to distinguish them from "Saxony" or Merino.
Combing	The removal of short fibre accompanied by the ordering of the longer ones in parallel positions.
Condition	The proportion of water present in tops and yarns.
Crabbing	A treatment to prevent the shrinking or cockling of cloth in the subsequent processes of dyeing and finishing.
Cuttling	Plaiting cloth in folds.
Doubling	Twisting together two single yarns to make a twofold.
Drawing	Preparing the combed top for the spinning frame by reducing it to "roving."
Ends	Warp threads.
Extract	Woollen material recovered by chemical means from mixtures containing vegetable matter.
Genapping or Gassing	Burning off the surface fibre from yarn to produce a more lustrous thread.
Gilling	An operation for straightening worsted fibre and intermixing differently coloured tops to secure an even admixture.
Hank	In worsted 7 wraps or leas of 80 yds. = 560 yds. In cotton and spun silk 7 leas of 120 yds. = 840 yds.
Hog	A yearling sheep; hog wool is the first clip from the animal.

LUSTRE	A name applied generically to the mohair alpaca and bright wool industry; specifically implies bright, long wools, principally English-grown.
MERINO	Wool of the Merino sheep; in hosiery a mixture of cotton and wool; the name of wool dress goods principally produced in France; certain rags are known as merinos.
MILLING	A process designed to felt or consolidate cloth or to break out ends of fibre from the yarn.
MIXTURE	Mixture shade in contradistinction to solid shade; formed by blending differently coloured loose fibres. A mixture effect in cloth is a varied but patternless one.
MOHAIR	Wool of the Angora goat (Capridae Angora).
MULE	Machine for producing a full, soft yarn.
MUNGO	Woollen fibre recovered from milled or hard cloth; mungo is shorter than shoddy.
NOIL	Short fibre removed by the woolcomb.
PACK	240 lbs. of wool.
PICKS	Weft threads.
RE-COMBING	A second combing given after tops have been dyed.
REGAIN	The natural or conventional allowance of moisture in tops and yarn; the difference between a state of bone dryness and the moister state due to absorption of atmospheric water.
ROVING	Lightly twisted sliver reduced in diameter in readiness for spinning.
SAXONY	The Scotch name for fine or merino wools.
SCOURING	Washing free from grease and dirt.
SHED	The parting formed in the warp threads during weaving to admit the shuttle.
SHODDY	The product of soft rags.
SIZING	Animal or vegetable matter applied to warps to reduce chafing in weaving.
SKEIN	Woollen yarn is numbered by skeins instead of by hanks. A Leeds or Huddersfield skein = 256 yds.
SKIN WOOL	Wool removed from sheep skins by sweating or fermentation.
SLIPE	Wool removed from sheepskins by the aid of lime.
SLIVER	Fibre arranged in a continuous loose rope or ribbon.
SLUBS	Thick places in yarn.
STUFFS	Light weight fabrics for linings and dresses, usually having cotton warps.

TENDER	Material deficient in tensile strength.
TENTERING	The operation of holding or stretching the width of cloth.
TOP	The long fibre delivered by the wool comb.
UNION	Denotes warp of one material, weft of another.
WETHER	In opposition to hog; wool from the second and subsequent annual shearing.
WOOLLEN	Used in contradistinction to worsted, implies difference of material and of method of manufacture. Wastes, shoddy, and blends of material other than wool are referred to as "woollen" in opposition to "all wool."
YOLK	The grease in wool.

APPENDIX

FIRE HAZARDS OF WOOLLEN MILLS AND WOOLLEN WAREHOUSES

By Robert Taylor, F.C.I.I.

If one were to review all the fire hazards incidental to the treatment of "wool"—during its conversion from the raw material to the finished product—it would be necessary to consider them as they arise in the processes of both woollen and worsted manufacture, but in the fire hazards of woollen manufacture and of woollen warehouses there is matter enough for this appendix, and the fire hazards of worsted manufacture will have separate treatment in due course in the volume on *The Worsted Industry*.

The readers of this textbook will have noticed that the broad differences between woollen and worsted manufacture declare themselves in the wool selected, in the treatment of the wool in each industry, and consequentially in the texture of the cloth produced. In woollen manufacture, all kinds of wool are used and are mixed sometimes with other materials in criss-cross fashion, this treatment accentuating this mixture so that finally the material has felt-like qualities which manifest themselves also in the cloth produced. In worsted mills, on the other hand, shorter or broken strands of wool are as a rule rejected, only the long strands of wool being usually used. In the yarn produced in the processes of combing and drawing and spinning, and also in the cloth woven from such yarn, the individual strands are observable.

In woollen manufacture, four classes of material are used, viz., wool, rags, wastes, and cotton ; and distinct fire hazards arise in the treatment of each of these classes of material. Each class of material undergoes different preparatory processes prior to teasing (which is also a preparatory process), these being, in the case of wool, Sorting, Drying, Burring, and possibly Carbonizing ; in the case of rags, Sorting, Shaking, Oiling and Grinding—and if the material contains cotton, Carbonizing, the recovered woollen material being " Mungo " (if from " hard " rags) or " Shoddy " (if from " soft " rags) ; in the case of wastes (other than noils), Shaking, and (if " hard " waste), Garnetting. Raw cotton or cotton wastes, or other vegetable fibre, may be used as a blend with mungo and/or shoddy, and/or pure wool, if the woollen fibres be short and weak ; cotton, being a hollow fibre, is more hazardous than such a solid fibre as wool.

The further preparatory processes in woollen manufacture up to teasing, are teasing by the shake-willey (each class of material being passed separately through this), blending and oiling, and a further teasing or willying process, continuous in the Fearnought or Cockspur machine, or intermittent in the ordinary machine. If only a pure wool yarn is being produced, this material will pass straight from the shake-willey, or teaser, to the scribbler.

Apart from the normal hazards incidental to all industrial risks, the special fire hazards of these preparatory processes lie in the arrangements for drying the materials and in the processes of rag-shaking and rag-grinding, garnetting, waste-opening, and willeying, burring and carbonizing, and in the blending and oiling of materials. All these processes may be found on woollen mill premises, but some of them, such as rag-grinding,

carbonizing for the production of extract material, and garnetting, are often carried on as separate trades.

The drying of materials over a boiler is a practice to be discouraged, whether the material being dried is wool or cotton. The practice is particularly to be condemned from the point of fire hazard in respect of cotton. If the drying is done on carbonizing premises, there is distinct risk of explosion from the dust given off in carbonizing. This risk of dust explosion exists also in the processes of rag-shaking and of burring.

The risk of sparking constitutes the most serious fire hazard in the processes of rag-shaking, rag-grinding, garnetting or waste-opening and willeying, and is caused by foreign substances such as buttons, buckles, hooks and eyes, and other hard substances coming into contact with the internal metal attachments of the machines through which the materials treated may be passed. It is most serious in the case of the rag-grinding machine, aptly called a " Devil." According to the Scriptural phrase, " The Devil goes about as a roaring lion, seeking whom he can devour." The name has probably been given to the rag-grinder, because of the manner in which it works. With considerable noise, revolving 550 to 650 times a minute, it pulls and tears the material fed into it. The fire hazard in this process is accentuated by the preparatory oiling of the rags for the purpose of enabling the fibres to glide together, and so produce a better result in the later spinning process. Often an inferior quality of oil is used, and the oiling of the material, whilst facilitating grinding, will help to spread a fire if one breaks out.

Another fire hazard exists on rag-grinding premises from " fly " or " fluff," where the material being pulled contains a considerable percentage of cotton, and this fire hazard is accentuated by the use of naked lights

The risk of spontaneous combustion also is present, if the material being pulled is soft rags or bags which have been used in the expression of oil from any seed. Such material may be used in blanket mills. As a preventive to the spread of a fire which may break out in a rag-grinding machine, the installation of a steam jet operating inside the machine is desirable. All fire hazards of rag-grinding are probably accentuated if the process is conducted by a commission rag-grinder. His premises may be less substantial than those of a woollen mill, he may use only a very low-class oil on the material treated, and there may be little or no management. Rag-grinding risks form the heaviest risks incidental to woollen manufacture, and many companies do not underwrite them.

Rag-shaking and rag-grinding, garnetting and willeying, should be carried on in separate buildings or in separate compartments only communicating with the mill by fire-proof doors, or, better still, by a fire-proof compartment with iron door at each end. The " blow-hole " attached to the rag-grinding room should be fire-proof, and be fitted with a substantial iron- or metal-covered door with adequate bolt or latch.

Blending and oiling are usually carried on in the willey house, and the fire hazards of willeying already mentioned are increased by these processes. The fire hazards are inherent in the processes themselves. Blending is done by the super-imposing of different materials on the top of one another, each in turn (exeept any layer of cotton) being oiled by large cans with rose attachment and beaten down before the next layer is laid down, the total height of the material being finally about six feet. If a fire breaks out, there is thus, in blending, material ready to spread a fire, especially if cotton is used in the blend and naked lights are used. The addition of

mineral oil used in blending will minimize the risk of spontaneous combustion which otherwise exists in respect of cotton under heavy pressure, if the oil used contains fatty matter.

The oils used in blending are: Oleines, olive oil, black oil and mineral oils. Olive oil is the best possible, but it is so dear as to be suitable only for certain classes of production. Black oil, which is commonly used in low-grade manufacture, is the oil "recovered" as a by-product, and not prepared or purified by saponification or distillation. Mineral oils are used a good deal, but they are objectionable from a trade point of view because of the scouring which is afterwards required to remove from the material the mineral oil or hydrocarbon, and their use increases the fire hazard of woollen manufacture, because they help to spread a fire, once started. Fish oils, most seed oils, and resins, have a distinct fire hazard owing to their oxidizing qualities. Fortunately, even from the trade point of view, they do not work well. Spinners, in the use of an oil to be used in blending, should stipulate for oils with a certain percentage of saponifiable or fatty matter, and having a safe flash-point. In a blend, "bought-waste" is not infrequently used, and it is important to find out what oil has been used on the material from which this waste comes. A spinner using a comparatively innocuous oil in the treatment of the material he is using may nullify all his care if an inferior oil has been used on material from which has come the "bought-waste" he may be working up.

Following the preparatory processes named, the further main processes in the making of yarn, no matter what materials are used, are scribbling, carding, condensing, spinning (mule or ring) and twisting. If felt is to be produced no spinning or twisting is done, but

there may be printing. The special fire hazards in scribbling, carding and condensing, arise from the oiled material, from the " fud " or heavy oil waste beneath the machine, from " fluff " or " fly " about the floor of the machine, or the sheets separating one machine from another, or from friction. Those sheets which are put up to prevent fluff from one machine working on a certain class of material, being carried to a machine working on a different material, should be treated with a composition so as to render them non-inflammable. It is important to see that no great pile of stock is kept in the scribbling room of a mill. In the scribblers themselves there may be considerable aggregation of value. They are substantial machines, with very delicate parts, and in the event of a fire, where complete destruction has not occurred, substantial saving in the loss may be made by oiling the parts which have been affected by water. In a sprinklered risk this is a matter distinctly to keep in view. In mule spinning the fire hazards arise from friction in the head-stock, and they increase if much cotton has been used in the materials from which the yarn is being spun. Hazard also arises from the oily floors and from sweepings.

Weaving sheds seem comparatively innocuous risks, but serious losses occur even in such risks, and the explanation will probably be found to lie in the fact that they often communicate with, or are contiguous to, storied buildings, where preparatory and/or finishing processes incidental to the manufacture of cloth are carried on, or where raw materials, such as rags and waste, are stored. If weaving is being done on the Jacquard loom, and gas lights are used, there is considerable hazard of a serious fire occurring if any of the strands of the harness break and fall into the lights. The storage of Jacquard loom harness requires attention, also of

the healds, which are an integral part of any loom, and the arrangements for the varnishing and drying of the healds also require attention.

Dyeing may be done on woollen mill premises, the dyeing being either of raw material (loose scoured wool) or yarn (for fancy cloths), or in the piece (from the grey). There is also on some woollen mill premises a plant for " oil recovery."

The warehouses of woollen mill premises may be wool warehouses, rag and waste warehouses, or cotton warehouses, or yarn warehouses, and/or cloth warehouses ; the most important from the point of view of fire hazard are the rag and waste warehouses. Even when the raw material stores are separate, there is, not infrequently, a menace to the manufacturing section of the risk owing to the congestion of the premises. In my own experience a fire, which assumed the character of a conflagration, started in a raw material store, where " bought-waste " was stored. On inquiry, it was found that this " bought-waste " had been pulled from material on which an inferior oil had been used. Near this material, if not actually touching it, there was a steam pipe or steam chest, and there was therefore strong probability that this serious fire was caused by the spontaneous combustion of this " bought waste."

We may now pass from the consideration of the particular fire hazard of individual processes in woollen manufacture to consideration of the more general fire hazards existing on woollen mill premises, keeping in view also the possible aggregation of these hazards through congestion of the premises.

The buildings on the premises of a woollen mill are generally substantial and frequently fireproof ; the fireproofing being sometimes of old type, such as brick arching. Rag and waste warehouses, on the other hand,

may be of corrugated iron construction, and I have known a fire which started in a storied building, with a favouring wind, to leap a yard space fifty feet wide, making the corrugated iron red hot, and so setting alight the raw material in the shed, both buildings and contents being more or less totally destroyed. Normally, this shed and the storied building (which was of substantial construction) would be regarded as separate risks, but the possibility of such a conflagration suggests the necessity for modifying what would be a normal retention on the two risks separately. Height does not as a rule present any additional hazard in a woollen mill, and lighting also, as a rule, is normal, but in little country mills it may be necessary to resort to oil lamps. As regards power also, only a normal fire hazard exists on woollen mill premises, and the same may be said in respect of openings, linings, and partitions. If any additional hazard exists from these, they are more likely to be found in rag and waste warehouses. Heating, on the other hand, may present an additional hazard, where hot air is used in any process, or super-heated steam is used. Even where only live steam is used, the pipes conveying this should be kept free from contact with woodwork or other combustible material, and this is still more essential where super-heated steam (i.e. steam entering the pipes at a temperature exceeding 350° Fahrenheit) is used. Even ordinary live steam will desiccate wood with which pipes conveying it are in contact, and if the pipes conveying the steam are rusty there is, through absorption of oxygen by the wood, now partly carbonized, all the material for starting a fire.

The question of management is of prime importance in the matter of fire hazards on woollen mill premises, and will include, among other things, adequate control

during periods of night work, and in ensuring that the premises are kept clean, wastes being removed daily or weekly, according to the character of the waste. All waste from any process up to scribbling should be removed daily, and other waste, including greasy cleaning cloths, weekly. Cotton waste, or " wipes " which have been used for cleaning machinery, should also be removed daily, and proper management will provide for such arrangements for the lubrication of shafting, etc., as will reduce to a minimum the possibility of fire from friction, by having bevel wheels enclosed in metal and " drip pans " provided for oil droppings. The keeping of the machinery in good working order and adequate arrangements for the closing of fire-proof doors, are also signs of good management.

The reader of the preceding pages will have seen that there are a number of risks which may be classed as woollen mills other than the woollen mill properly so-called, namely, such risks as tweed mills, blanket mills, flannel and shawl mills, and carpet mills. He will have learned something of the geographical distribution of the various risks engaged in woollen manufacture, and will have noted that those in which the heaviest fire hazards occur—rag-grinding and angola yarn spinning, where often 90 per cent of cotton may be used, are practically confined to Yorkshire. If he acquire a knowledge of fire insurance underwriting, he will appreciate that the quality of the materials used and of the goods manufactured in any risk may be taken as a measure of the fire hazard of the risk, and as a conclusion of the whole matter he will probably determine that an old mill where high-class goods are made is better worth having on his books than a modern mill where mungo and shoddy and cotton are the principal materials used.

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